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Fig. 1.—Driving Concrete Piles at Elwood Bend, Missouri.

AIDS TO NAVIGATION ON THE MISSOURI RIVER.—[See page 100.]

Some Alloys Suitable for Instrument Work—II*

A Neglected Field for Investigation

By W. Rosenhain

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 1936, page 83, February 8, 1913

THE second group of alloys described in the reports mentioned in our last issue, which are of interest to instrument makers, are the light alloys consisting principally of aluminium. The use of light metals in instrument making appears at the present time to be unduly restricted. There is no doubt that here, as elsewhere, the excessive claims made for aluminium in the early days of that industry are much to blame in creating disappointment and subsequent prejudice. Not only were the claims advanced far beyond the truth, but the aluminium which was available in the early stages of the industry was far less pure, and in many ways far less satisfactory, than that which is now obtainable, while the recent very marked drop in the price of aluminium has also materially changed the situation. The time has, therefore, arrived, when the attention of instrument makers should be seriously directed toward the materials now available, and particularly to the fact that many of the alloys possess properties far superior to those of aluminium itself. As regards the pure metal itself it undoubtedly possesses the fundamental advantage of lightness coupled with very great ductility and very high conductivity, both thermal and electric. On the other hand it is weak, and can only be rendered stiff enough for most practical purposes by cold work, and reasons have already been given why it is not desirable to rely upon cold work to provide the necessary strength in our materials. Further, pure aluminium is in some respects difficult to machine, particularly at high speeds, but it possesses the curious property that its qualities in this respect are much improved by age. It is found that freshly cast aluminium is much more difficult to machine than the same material which has been allowed to rest for several months. Finally, aluminium itself possesses the very unpleasant property of being very easily abraded; even when severely rubbed with the fingers it is apt to produce a slight metallic stain. Most of these disadvantages are absent from the best of the light alloys, but these again have certain difficulties to contend with.

In the first place, a very considerable number of light alloys have from time to time been placed on the market with little more than a fanciful name to recommend them. While some of the commercially advertised light alloys are no doubt very useful, others are very much the reverse, being put together without any scientific study, while claims are advanced for them with little regard for the truth. As regards all such alloys it is desirable to ascertain whether they really possess the strength claimed for them, how they behave as regards corrosion, and whether they are subject to spontaneous disintegration or warping. Generally speaking the author would advise instrument makers to confine themselves either to alloys already well known to them from practical experience or to such new alloys as have had full and careful scientific investigation. It is not suggested that the alloys described below are in any sense the only ones to which this description applies; they are merely quoted here as examples with which the author is familiar from his own investigations.

The composition and properties of the light alloys, described in the three reports of the Alloys Research Committee referred to above, are given in Table II, this table being arranged in the same manner as Table I.

For the sake of comparison, under the reference No. VIII 33 the data for pure aluminium have been included. It will be seen that even in the cold-drawn condition it falls short of a tensile strength of 9 tons per square inch. Alloy No. VIII 37 represents the most favorable member of the series of alloys of aluminium with copper alone. In the form of rolled bar it attains a strength of 17 tons per square inch with an elongation of 21 per cent. In the cast state also this alloy is far superior to pure aluminium. An alloy of very similar properties is No. IX 11, which contains approximately 3 per cent of copper and 1 per cent of manganese. In itself this alloy is not very much superior, as regards mechanical properties, to No. VIII 37, but it possesses two points of special interest. In the first place the presence of manganese appears to reduce the tendency of these alloys to undergo corrosion in sea-water; at all events there is good reason to believe that IX 11 is superior to pure aluminium in this respect. Machined specimens of this alloy on exposure to sea-water become coated with a dark-colored patina, which appears to act to some extent as a protective covering. A further point of interest about this alloy is that it forms the basis from which has been derived the light alloy commercially known as Duralumin. This remarkable substance owes its superiority to IX 11 to the presence in it of 0.5 per cent of magnesium. The presence of this small proportion of magnesium appears to confer upon the alloy the property of hardening gradually after a particular kind of heat treatment, and as a result of this process, while the ductility is slightly reduced, the tensile strength is very nearly doubled.

Alloy No. X 20 may be regarded as probably the best alloy of the aluminium-zinc series. Castings of this material attain a tensile strength of over 13 tons per square inch, but show very little ductility. The rolled bar on the other hand attains a tensile strength of 26.6 tons combined with an elongation of over 20 per cent. It will be noticed that both this and the next following alloy, X 25.3 show specific gravities materially higher than the first three metals in the table, and in the latter case particularly it might be urged that lightness has been too much sacrificed by the addition of such considerable proportions of zinc as 20 and 25 per cent. The figures in the last column of the table, headed "Specific Tenacity," have been added in order to show the relation of strength and weight in a correct light. The specific tenacity as there tabulated is defined as the breaking stress in tons per square inch divided by the weight of a cubic inch in pounds. The figure may also be regarded as presenting the breaking load of a bar of such cross section that every inch-length of it weighs 1 pound. So far as strength is concerned this quantity may be regarded as a figure of merit for the alloy, and it will be seen that this is by far the lowest in pure aluminium, although this is the lightest material in the table, and the maximum value of the specific tenacity is found in the alloy X 25.3. For the sake of comparison it may be stated that the specific tenacity of mild steel on the same definition is 105. It should also be noted that when materials of different specific tenacities are compared, as regards their strength when used as beams, the comparison in favor of the material of higher specific tenacity is still more marked, since for a given weight of beam not only the areas of the flanges, but also the depth of the beam, is proportionately increased. The value of such an alloy as X 25.3 in the cast form where no particular ductility is necessary is obvious from the figures given in the table, and it may be stated that no difficulty attaches to the casting of this alloy. The process of rolling it into bars, however, entails a certain amount of difficulty which has yet to be overcome on the commercial scale, but in view of the high ductility which the alloy develops when rolled hot it appears probable that means could be found for producing in this metal both tubes and other desired sections.

As regards corrosion, there is no doubt that both aluminium and its alloys are not as resistant as might be desired. Certain of the alloys, as has already been indicated, as slightly superior to the pure metal, but the great majority of them are slightly more corrodible. In most cases, however, and certainly in all those described in Table II, this corrosion is not very marked so far as exposure to the air is concerned. To obtain this result, however, it is essential that any zinc which may be used in the manufacture of the alloys shall be of the purest kind obtainable. The presence of impurities, and particularly of lead, tends to increase the rate of corrosion in these alloys very materially. On the whole it may be taken that aluminium and its alloys are not more corrodible than iron or steel; and particularly where their surfaces are not subject to friction, and the protective coating is allowed to form itself, the corrodibility is very much smaller than that of iron. None the less, in the case of instruments exposed to adverse conditions, the protection of light alloy surfaces against corrosion is eminently desirable. For this purpose most of the ordinary protective coverings may be used, but it is an essential condition to the successful use of these materials that any source of electrolytic action should be carefully avoided. This implies that light alloys must not be brought into contact with other metals, particularly with copper and brass, in circumstances where the presence of moisture will facilitate electrolytic action. Where such action is set up extremely rapid corrosion of the aluminium alloy will result; but a little care on the part of the designer or constructor of the instrument will suffice to avoid this source of deterioration.

The above brief account of some of the properties of a few special alloys, which have been investigated at the National Physical Laboratory, has been given in the hope of arousing in instrument makers an interest in the fresh developments which are taking place in this country and abroad in the production of new and valuable materials on the basis of our increasing knowledge of alloys and their properties. It is hoped that if such interest be aroused important results may follow, for not only may many existing instruments be improved by the use of superior materials, but other and new problems in instrument making may prove to be capable of solution by their aid.

* Paper read at the recent Optical Convention.

TABLE II.

Light Alloys Consisting Principally of Aluminium

Reference Number.	Composition. Al.	Cu.	Mn.	Zn.	Condition.	Strength. Yield Point. (Tons per sq. inch).	Strength. Breaking Stress. (Tons per sq. inch).	Ductility. Elongation per cent. on 2 inches.	Density.	Specific Tenacity.
VIII. 33	Pure Aluminium				Sand Casting	2·5	4·9	24·0	2·69	50·5
,,	,,				Chill Casting	2·3	5·22	37·0	2·71	53·4
,,	,,				Rolled Bar	6·5	7·20	30·5	2·71	73·6
,,	,,				Cold-drawn Bar	8·5	8·70	19·5	2·71	89·9
VIII. 37	96·24	3·76	—	—	Sand Casting	4·9	7·49	5·0	2·77	74·92
,,	,,	,,	—	—	Chill Casting	5·4	9·60	10·5	2·79	95·3
,,	,,	,,	—	—	Rolled Bar	11·6	17·00	21·0	2·79	168·8
,,	,,	,,	—	—	Cold-drawn Bar	18·5	20·00	7·5	2·79	198·6
IX. 11	96·17	2·89	0·94	—	Sand Casting	6·0	7·48	5·0	2·67	77·61
,,	,,	,,	,,	—	Chill Casting	7·27	12·05	13·5	2·74	121·7
,,	,,	,,	,,	—	Rolled Bar	12·80	16·50	15·0	2·79	163·9
X. 20	79·85	—	—	20·15	Sand Casting	10·00	13·07	0·7	3·06	118·2
,,	,,	—	—	,,	Chill Casting	7·80	13·82	4·0	3·08	123·6
,,	,,	—	—	,,	Rolled Bar	17·30	22·64	20·5	3·09	202·3
,,	,,	—	—	,,	Cold-drawn Bar	19·90	22·30	12·7	3·09	199·9
X. 25.3	72	3	—	25	Sand Casting	5·71	18·25	2·0	3·26	155·1
,,	,,	,,	—	,,	Chill Casting	5·63	20·22	3·5	3·27	171·3
,,	,,	,,	—	,,	Rolled Bar	21·76	30·91	16·75	3·29	260·3
,,	,,	,,	—	,,	Cold-drawn Bar	31·50	33·30	13·00	3·29	279

An Unforseen Function of the Beard of Wheat

WHEAT growers in general do not favor long-bearded grain, as the straw made therefrom is not liked by barn animals. Still, in windy regions the beard of wheat is found to act as a protection, its elasticity keeping the plants from injury. It also checks the inroads of birds. But quite a new function of the pointed bristles has been discovered, according to *La Nature*, by Prof. Lemstron of the university of Helsingfors, who points out that the points of the bristles dissipate electricity, acting somewhat like miniature lightning conductors.

Wood Waste Utilization*

The Industry in Its Relation to Expert Advice

By John E. Teeple, Ph.D.

HERE is an industry expanding and changing so rapidly that it is difficult to keep abreast of its progress. Every time I attempt a general review, its aspect has changed.

Processes and patents without number loom above the horizon. Most of them die without ever seeing the light of day in a commercial form, many never advancing beyond the paper and ink stage. Some start life hopefully, only to draw out a weary existence suffering from the disease known as "annual deficits." They approach so near death that when existence ceases and the scrap heap receives them we hardly notice the change.

A few, either sturdy by nature or well provided with nurses and doctors, live and grow to the mature form known as "dividend payers." These are rare, much rarer than need be if proper skill and experience were only called in at the birth of all. Like other infants their death rate is very high in the early period of existence. Fortunately, in this case, the doctor has no compunctions about letting an unpromising one die, or drowning it if need be for the good of the community.

The net results to date have been disappointing. The rewards have been few. The number of plants that have been on a real dividend paying basis for the last two years could be counted on the fingers of a one-armed man. On the other hand the crop of white hopes is large. The prospects of the industry as a whole were never better than they are to-day. A very respectable number of plants have recently started or are in process of construction. Most of these efforts show a very decided advance over those we have seen spring up in previous years.

In nearly every case, actual construction of the plant has been preceded by an investigation of the process by competent and experienced experts, and also by tests on a semi-commercial scale. Then there has been careful study of the type of raw material to be used, of the finished products and their marketability as judged by men who were thoroughly familiar with those markets, and finally an intelligent adaptation of the design and construction and location of the plant, both to the raw materials and to the finished products.

These may seem like too childish or self-evident precautions to receive special mention here, but it must be confessed that in the past, often many and sometimes all of them have been overlooked in constructing plants. Too often the process has been the whole thing. The man with a process and a long array of figures showing what wonderful products in amount and value he could get from a cord of wood, has frequently carried the investor by storm. Without waiting for the advice and experience of men who have spent years in the industry, as he would normally do in any other line, the investor plunged. There must be something fascinating about the industry, like there is about buying a mine, but nowadays even the mine buyers have an expert examination and report before buying.

A man with a process and a man with money sat at a mahogany desk. The process and the usual array of figures were there. The figures showed that from a cord of wood, kind and quality not specified, you could get wood alcohol, acetone, acetic acid, acetate of lime, turpentine, rosin, tar, pitch, oil of tar, creosote oil, sheep dip, disinfectant, wood preserver, cable coating, pine oil, liniments for man and beast and rheumatism, cough syrups, patent medicines, embalming fluids and guaiacol, and high-priced drugs of the pharmacopœia.

Of course, it was all more or less true. The beauty of it is that you *can* get these, but the question is, Do you want to? This particular investor did want to. He verified some of the prices from *Merck's Index* and the *Oil, Paint and Drug Reporter* and added the long column of figures.

The fact that if you used up your raw material in making some of the products you couldn't have it left to make the others too, didn't occur to him. Further, he forgot that few of the products could be obtained from all woods, that some would certainly be obtained from certain woods in an entirely unsalable condition, and others would cost more to make and refine in most cases than they could be sold for; still others would glut the market from one day's run of his plant, still others would probably be so different from standard articles, that their use would be restricted to special industries at much lower prices.

Overlooking all these things he followed a common practice of investors in arriving at a conclusion. He took the huge total of returns and deducted 50 per cent, then he deducted 50 per cent of the remainder. After providing this factor of safety, the total was still so large that it seemed certain a handsome profit would result no matter how it was handled. In fact, it seemed a shameful waste to use mahogany desks for office furniture when such rich returns could be obtained by distilling them. After the plant was built it was my painful duty to clear away the sad remains before it had produced a thousand gallons of anything or sold a cent's worth.

This was years ago, but I could cite many almost as bad in more recent years. There was a plant that ran intermittently almost a year without ever producing a single gallon of really marketable goods, and the men in charge did not know tar from pitch, and still no one was called in during that whole period to advise them.

There was another plant with a marketable process where the plant was designed and built complete, and only after the initial operation was started did they discover a glaring mechanical defect that made the plant as constructed, an impossibility.

There was a plant built to handle mill waste where the yields were small but a profit possible because the raw materials cost nothing, and then the whole was laid out so that every stick of wood had to be *handled twice by hand* before reaching the plant.

There was a plant constructed where raw material in the shape of lightwood was "countless as the stars," and investigation showed later that if lightwood of the kind desired was meant, the stars must have been counted on a very cloudy night.

But why continue the enumeration? It seems like a record of one case after another of useless waste. And we wonder about the high cost of living. Literally the amount unwisely expended in this industry amounts to millions. And it is not because we are lacking in competent chemical and engineering information and experience here. It is chiefly because the idea of the *process* has been overrated.

The man who can invent and think out a real idea suitable for a process has done his share. In nearly every other industry we realize that the type of mind capable of inventing is not the type most suitable for designing and constructing or managing a plant or for developing and criticizing his own process intelligently.

Why in this industry do we so magnify process and expect the inventor to be more superhuman than we do elsewhere? Why do we load him with the whole responsibility of success or failure instead of calling in the best man available to his assistance? And why do we invest in this industry on an interested man's mere word without calling in competent advice?

Within this present year I talked with an inventor anxious to interest capital in his process of recovering turpentine and rosin from wood. The conversation developed his supposition that no one else was doing this or had workable methods for doing it, and that the only thing he had to compete with was the destructive distilling type plant of thirty years ago. If the inventor, supposed to be expert in his subject, thinks this, why should we be surprised if he convinces the investor?

The process is one element of success; a good process is necessary, yes, but it is only one element, and there are many others. The character and cost of the raw material is most important and deserves an article by itself. The marketability of products has been overlooked again and again on the assumption that turpentine is turpentine and rosin is rosin. Sometimes they are, and sometimes they are not. The fact that John Jones sold his druggist a gallon of pine oil for ten dollars doesn't give you a clue as to its price and consumption in tank car lots. If you read that light oil or heavy oil is quoted at fifteen cents per gallon, that does not indicate that you can sell light oil or heavy oil from white pine at that price, or necessarily at any price.

There is really just one way to determine the marketability and price of a product and that is to sell it or products identical with it on the open market. And then, as mentioned before, the location of plant as related to raw material and market, the design, construction and management should all be done in consultation with men who have been handling this same type of installation as chemists and engineers.

A frequent mistake lies in placing the problem before an analytical chemist. He may be an exceptionally good chemist, and may give accurate reports that will be entirely misleading through no fault of his own. I have before me now such a report on a process made by a thoroughly competent analytical chemist. The report so far as I can see was correct in all respects. Unfortunately, however, from lack of specific information which he could not be supposed to possess, the report indicated success to the chemist and to the investor. A single reading of it would have convinced a man experienced in the industry that nothing but failure lay ahead, unless many things were radically changed. The report actually led to one more useless expenditure of money.

It seems probable that nearly every possible error has been made at some place or time. Most of the mistakes could have been avoided if competent experts, of whom there are a sufficient number, had been kept in touch with the work from its inception. Unfortunately in many cases the man of training and experience in this particular industry has never been called in at all. In other cases he comes to give decent interment or shorten useless suffering. Why not call him in at the beginning, in time to announce to the proud father the arrival of a bouncing baby boy?

*Reproduced from *Metallurgical and Chemical Engineering*.

The Work of Filing

IN further development of the investigations of Taylor in America, and Prof. Imbert at Montpellier, M. Jules Amar publishes in the *Comptes Rendus* some quantitative studies of the work of filing.

Since the expenditure of energy by the workman is measured by his consumption of oxygen, Marey's graphical methods enable us to determine the muscular effort, the useful work, and the corresponding expenditure of energy. It is then only necessary to change each element of the work; its speed, its total duration, the attitude of the workman, and the form and dimensions of the tool, in order to find the best working conditions. The number of "variables" is generally very great. Some are mechanical, others physiological. The file employed was of medium hardness, and the length of stroke varied from 10 inches to 13 inches. The material worked was brass. The workman was provided with a respiration-valve, for measuring the oxygen consumed. The chief conclusions arrived at are as follows:

1. The weight of filings taken off is generally proportional to the mechanical work, which equals the product of the length of stroke into the horizontal component of the muscular effort.

2. The rhythm of the stroke affects the quantity of work done. It varies in different individuals, but it increases the work performed up to 79 strokes per minute (about the frequency of the pulse).

3. The expenditure of work per weight of filings is less for frequent strokes than for a slow rhythm. Seventy strokes per minute is about the best.

4. The attitude of the body, whether straight or bent, its oscillations, its distance from the vice, the inclination of the arms, the inequality of their action, and the position of the feet, modify the expenditure of energy.

5. The conditions of highest efficiency are: Body straight, but not stiff, 8 inches from the vice, which must be at the level of the navel. Angle between the feet, 68 degrees, with a distance of 10 inches between the heels (in the adult). Left arm fully extended, and pressing on the tool a little more than the right, the pressures being about 16 pounds and 17 pounds, respectively. Return stroke an easy glide, and a rhythm of 70 strokes per minute of complete rest, arms hanging straight down. In practice, fitters are employed 8½ hours per day, of which 7 hours are effective work. This comes to 470,000 feet-pound of work per day, and should yield 1 pound 3 ounces of brass filings.

This improved method increases the output of apprentices some 66 per cent. Fatigue is greatly reduced; respiration and pulsation undergo only half the usual increase; there is no pain in the forearm; and all irregular muscular action is done away with.

The graphic records of the work of different operatives give valuable indications concerning the differences due to the matter of age, experience, and physical condition.

It was observed both by Imbert and Taylor that apprentices show a well-marked irregularity in their muscular work.—*English Mechanic and World of Science.*

Fig. 2.—Lower End Upper Concrete Dike, Fort Riley, With Riprap Revetment.

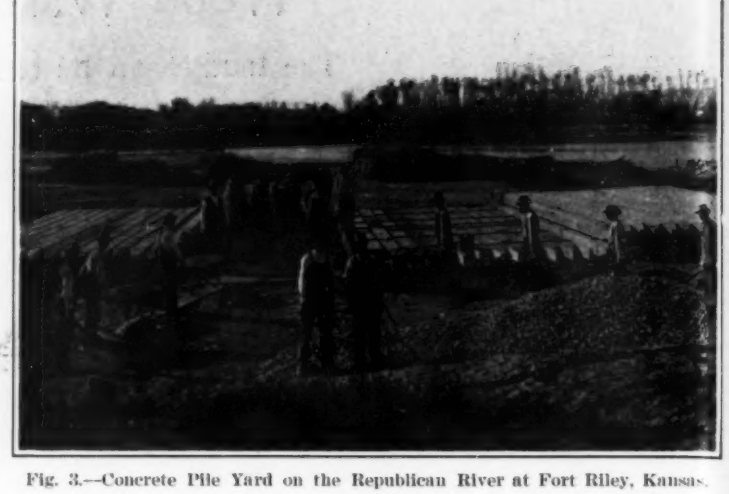


Fig. 3.—Concrete Pile Yard on the Republican River at Fort Riley, Kansas.

Aids to Navigation on the Missouri River

Concrete Piles Employed in Dam Construction

By Frank C. Perkins

THE accompanying illustrations show the development of the regulation works and the concrete improvement of the Missouri River at Elwood Bend, Mo., and Fort Riley, Kansas. For data and photographs the writer is indebted to Maj. Edward H. Schulz of the Corps of Engineers, U. S. Army, having charge of the improvement of the Missouri River and its tributaries.

The valley of the river is composed of alluvium, which is readily acted upon by the river currents. In its winding and wandering course between the bluffs, the river is continuously eroding and redepositing this soil, thus changing and forming bars and interfering with navigation. It has been estimated that sediment to the extent of about 400,000,000 tons annually is brought down by the Missouri and washed into the Mississippi River.

In order to improve and regulate the river, snagging, bank protection and channel contraction have been used. Dredging has practically never been utilized on the Missouri River, though its use may be necessary to overcome temporary obstructions to navigation. Snagging has been carried on for many years and has been of great value in opening channels and giving safety to navigation.

There have been two principal methods of bank protection and regulation developed. The revetment method protects and holds existing banks and the longitudinal, diagonal and spur dike method holds the banks, guides the channel, and contracts the flow.

The timber pile built along the Missouri River have an average life of from seven to ten years and usually the cause of their removal in that time is decay about the water line; but very often floods, erosion, floating ice and drift destroy them before they actually wear out.

With the idea that concrete would resist both deteriorating influences of rot and exterior abrasive or destructive action, the construction of a concrete dike was authorized, in order to test the value of concrete, at Elwood Bend above St. Joseph, Mo. This dike, shown in the accompanying photograph, is believed to be the first concrete dike of its kind in any river improvement.

The total length of this dike is 150 feet, of which 40 feet, near shore, was timber, and the remaining 110 feet were built of concrete piles. The length of the piles varied between 32 and 50 feet, the penetration being, on an average, 21 feet. The elevation of the top of the piles was 10 feet above standard low water, the cross section of the piles being 14 inches square at the top and 8 inches square at the base. The reinforcement consisted of four bars of 1 inch square steel, and ½ inch round tie steel, 18 inches center to center.

The forms used were 2-inch yellow pine and the concrete mixture 1 part cement, 2 parts Missouri River sand, 4 parts crushed rock, largest size 1 inch. The weight of the 50-foot piles was 8,700 pounds each, and they were allowed to set 10 days before driving.

It is of interest to note that the concrete piles were cast on shore about 6 feet above a barge, on which they were skidded preparatory to being driven. On account of the weight of the pile, a wire cable, with a single and double block, was used in handling the material, slinging each pile at the large end and at about 15 feet from the small end to take care of the deflection under its own weight. It was found that a pile could bend 5 inches in the 50 feet without injuring it.

When driving in sand only, the piles were jetted down in about five minutes by means of a jet attached to a 1¼-inch pipe fastened along the pile. But in the part near the shore covered with rock and débris, considerable difficulty was experienced and the hammer had to be used. At first it was intended to build the piles only of concrete, tying them together with timber, but in a portion of the dike, concrete cross beams were substituted for the timber, as will be noted in the photograph.

The actual cost to the United States was $1.36 per lineal foot of pile, which, after deducting the expense for special supervision, would make the cost about $1.00 per lineal foot, a figure which could be expected to be reached by the Government in future work. The itemized cost of the construction is as follows:

Fig. 4.—Injury to Concrete Dike, Bonton Bend, by the Flood and Ice Gorge of Spring of 1912.

Invoice for supervising forms and steel rods	$1,200.00
Portland cement, 86¾ bbls. at $1.25 bbl.	108.44
Crushed rock, 111,800 lbs., at $1.30 ton.....	72.67
Sand, 32 cu. yds., at 20c. per cu. yd.	6.40
Labor, making forms	117.00
Labor, making piles	257.00
Labor, driving piles	215.00
	$1,977.21

It is said that this dike has stood the test of floods, ice, gorges and débris for the last three seasons and has suffered no loss, except in parts of the wood bracing destroyed by the ice.

A concrete dike was next constructed closing off the left hand chute of the Republican River above the Washington Street bridge at Fort Riley, Kansas, as noted in the accompanying illustrations (Figs. 2 and 3).

Above the bridge the river considerably eroded the left bank, and continued to such an extent that not only was the bridge threatened, but also a portion of the United States Military Reservation, amounting to about 20 acres. The normal width of the Republican River is from 400 to 600 feet. The shore length to be protected was about 3,600 feet, and to revet this entire line would have cost approximately $25,000. Such work would hold the present left bank, but would not materially assist in regulating the river or placing it in its old position.

Two concrete dikes were built, one closing the left chute, 800 feet long, extending from the main bank to the head of the island. This would not only close the chute, but cause the sand bar behind the island to fill in. The other concrete dike, 400 feet long, is constructed from the foot of the island toward the north end of bridge, with the effect of deflecting the channel to the middle spans of the bridge.

The concrete dike work is similar to that used near St. Joseph on the Missouri River, except that two row work was used instead of 3 row work, and the width of foot mattress reduced to 40 feet. The estimate for 1,200 linear feet of 2 row dike of yellow pine piles and braces with four buttress stay dikes and foot mattress, was $10,000, or $8.33 per linear foot. The estimate for 1,200 linear feet of 2 row dike of concrete piles and braces with foot mattress, but without stay dikes, was $15,000, or $12 per linear foot.

A concrete dike was decided upon, as from the experience previously gained there appeared certain advantages as to durability and strength not belonging to timber dikes, and the locality at Fort Riley was well suited for the purpose.

There were two types of concrete piles considered: one known as the rolled pile and the other as approximately rectangular pile, molded with steel reinforcement. The rolled pile could be furnished for about $1 per linear foot of pile, but all the machines were in operation, and the company could not do the work before spring. The rectangular cast piles were, therefore, adopted as they could easily be made by hired labor, and the concrete bracing and foot mattress would in either case have to be done by the United States.

The concrete piles used were approximately 11 inches square and 30 feet long, with an 8-inch point, reinforced with four steel bars of ¾ inch diameter with steel bands ½ inch diameter, spaced 24 inches between centers. The bracers were 8 by 8 inches and were cast in forms built in place, and were reinforced with four steel bars of ⅝ inch diameter. The number of concrete piles driven was 243 and the total lineal feet were 6,966.25 at 31½ cents making a total cost for driving of $2,194.37.

The foot mattress for the dike was woven in place ahead of the pile driving. The cost of the mat was unusually high, owing to the freight charges and long haul by team and the erection of scaffolds for weaving across the water. The screening poles were wired into place on the rear concrete bracing.

Besides the willow foot mattress, a system of flexible concrete blocks was laid for 23 feet at the end of the dike as indicated in photograph Fig. 2. The concrete

blocks are 18 inches square and 4 inches thick, reinforced by four crossed galvanized iron bars of ¼ inch diameter, with an eye turned on each end, to connect adjacent blocks. The eyes are 19 inches between centers, and the connection between blocks is made with a ¼ by 1 inch galvanized machine bolt. There were in all 300 blocks cast at a cost of $0.515 per block laid in place. The cost of the original two dikes, 800 and 400 feet, was approximately $11.37 per linear foot. The cost of the 300-foot extension, together with repairs, was approximately $21.80 per linear foot. The average cost per linear foot of the entire 1,500 feet of 2 row concrete dike, with repairs, was approximately $13.03 per linear foot, comparing favorably in cost with the usual timber pile dike and exceeding it in durability.

There was in addition to the dike construction 300 feet of willow revetment above the upper end of the 800-foot dike, and 100 feet below the lower end at head of island. The mattress was 45 feet wide, and the cost $6.40 per linear foot. The entire system has gone through the winter with its ice, débris and flood, without any injury. The fill in rear of island below the dike is now within 6 to 8 feet of the top of the dike, and it requires a considerable rise to go through the chute.

The third concrete dike construction was on the left bank of the Missouri River, above St. Joseph, and was built to protect an eroded pocket in an original revetment. This dike is 500 feet long and consists of three rows of concrete piles, spaced 10 feet center to center, braced with reinforced concrete beams and having the usual foot mattress, pole screen and paving of the wooden dike. The piles are 12 inches by 12 inches reinforced with 1 inch twisted bars tied with ¼ inch round iron every 24 inches, and are 35 to 50 feet long. The penetration is from 20 to 28 feet, and the tops are about 15 feet above standard low water. The braces are 8 inches wide, 9 inches deep and extend from pile to pile (about 9 feet) and are reinforced with four ¾-inch twisted bars tied with ¼-inch round iron every 24 inches.

There were willow screening poles wired to the braces of the center row of piles with No. 12 wire, and in casting the piles, holes were left through which the reinforcing bars of the lower braces were placed. The reinforcing bars in the piles were allowed to protrude about 6 inches at the top and the upper bracing system was built over the tops of the piles, thus bracing the entire structure securely together. One hundred and fifty-three piles, 6,564 feet in all, were cast and mainly sunk by jet.

This concrete dike was injured in the ice gorge and flood of spring of 1912. The damage consisted in breaking six piles and four braces at the lower end, disconnecting two piles on outer row and eroding the brush and rock fill at the lower end. The gorge broke at this locality and the crushing and pushing force was irresistible. The damage done on four wooden dikes a few hundred feet below was very much greater. The concrete dike will be repaired at once. The injury was a reasonable one and does not disprove the value of concrete for such structures.

There has been a further authorization for the construction of a concrete dike at Commerce Point, Pelican Bend, on the right bank of the Missouri River near the mouth. It is to be a three row concrete dike 4,500 feet long, and the estimated cost is $25 per linear foot, or about $112,500 for the total.

It is stated that the Pelican Bend has always been a bad stretch. The fall of the river along the chute to be closed is 1.18 feet per mile, while around the bend it is 0.77 foot, which agrees nearly with the average river slope. This dike is primarily for the rectification of the right bank, as it will close the main one of the numerous chutes in Pelican Bend. Its first service will be in closing the chute, and the second will be to act as a permanent structure and serve as revetment, hence the cost of a wooden dike, $15 per linear foot, for closing purposes, and the later construction of revetment at $10 per linear foot, for permanency are combined in the first cost of the concrete dike.

The Use of Relief Maps in Mine Surveying

A Realistic Model Often More Helpful Than a Plane Chart

By H. G. Henderson

At first sight the preparation of relief map models of the surface or underground indications of a mine would appear to be rather a refinement, hardly justified by the necessities of actual practical working, and this would be the case if everybody could clearly understand without the possibility of error, the markings contained on the ordinary mine plan. Unfortunately, however, one has to deal in mining work not only with the highly technical man, but also with those who although commercially able men, have not sufficient knowledge of the conventions of ordinary map drawing to enable them to see clearly and without confusion the whole of the information which a map is intended to convey. For this reason it is frequently found advisable to go to some little trouble and expense in preparing a more graphic and realistic model than the ordinary map, and this is found in the relief map model. It very frequently occurs in connection with the negotiations concerning the acquiring of, or the work involved in operating concessions that some means of conveying to a more or less untechnical person an idea of the actual conformation of the ground is necessary, and for this reason it is very desirable that a mine surveyor should be able to construct map models, or at any rate to supervise intelligently the process of constructing them. The uses of such map models have been demonstrated not only for educational purposes, but also in connection with law cases, and they are also very valuable adjuncts to the work of a directors' meeting. Sectional models can also be constructed on the same principle showing the position of affairs underground.

There are in practice two principal methods, and they are both based on a study of the contours of an ordinary surface plan. One method of constructing these models is to trace the contours off the map and transfer them accurately to a base board of moderately soft wood. When this is done ordinary pins of different length, these lengths being graduated so as to correspond with the vertical heights on the required scale, are inserted at frequent intervals along each contour. Thus these pins will form a species of skeleton

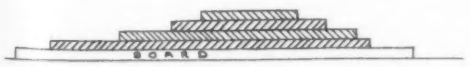


Fig. 2.

surface corresponding to the actual undulations of the ground. The model is then completed by filling in the skeleton with plaster of Paris or similar material. It will be seen, however, that this method, besides being slow and laborious, is apt to throw the model out of truth, possibly at some important point, if even but one of the pins is inserted beyond its depth in the wood, or is bent or is not strictly vertical.

For this reason the second method now to be described is far more accurate, and fairly easily carried out. In this method the contours are transferred in pairs from the map to thin sheets of wood or veneer. For example, in the illustration Fig. 1 a sheet of wood marked No. 1 would have contours *A* and *B* marked upon it; the sheet of wood No. 2 would have contours *B* and *C*, and No. 3 would have *C* and *D*, and so on. The top contour would, of course, have a separate con-

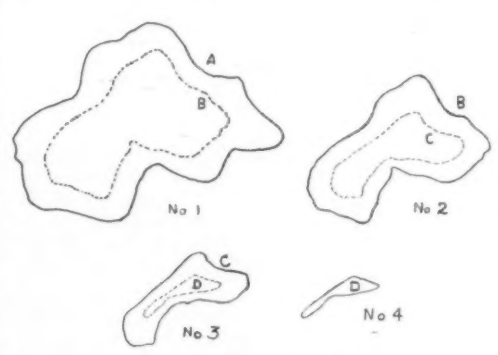


Fig. 1.

tour of wood or veneer to itself. All these pieces of wood or veneer are made of the same thicknesses. After they have been thus marked out the pieces of wood are then cut out along the outside contour with a fret saw. Following the process by the aid of the illustration, No. 1 piece, if this is the lowest piece of the model, is then taken and nailed down onto a base board by means of fine fret nails; No. 2 is then taken and nailed over No. 1, the exact position of its outer side (or contour *B*) being indicated on the first piece of wood by the inner contour *B* marked upon it. The second piece of wood is then nailed down to the first one, and the process is repeated with the subsequent number of layers until all the layers have been built up all over the map. When this has been done the model will then appear in sectional elevation somewhat as shown in Fig. 2. It will largely correspond to the actual undulations of the ground, but instead of being smooth they will, of course, be stepped in ridges corresponding to the contours. In order to reduce these inequalities to the actual surface appearance of the ground, plaster of Paris is then laid over the surface of the model and smoothed down until the elevation of the model appears somewhat as shown in Fig. 3. In this way a raised model representing actual surface conformation of the ground is obtained.

This method will be found to be most accurate, and some very valuable geological models made for the United States Government were constructed in this way out of thin wood cut into shape by means of a fret saw. The cutting of these thin sheets of veneer is, however, most laborious, and in addition to this it will be found that the wood is very apt to break in the process, very much trouble being incurred in fixing. After a very considerable amount of experiment the author devised a modification of the process which has given very satisfactory results in the construction of mining models. In this modification, double-faced corrugated brown paper, such as is now used so extensively for boxes, particularly for druggists preparations, as shown in the sketch, Fig. 4, is used instead of boards or veneer. This material can be obtained in large sheets, and has the merit of being both cheap and light. It was first thought that the inequalities in thickness of this material would be sufficient to render the vertical heights of a model constructed in this way liable to suspicion, but in practice this has been found not to be so. Instead of using an awkward and slow moving fret saw, it will be found that a sharp knife can be employed to very quickly run round the required contour. In order to fix each layer in place ordinary glue is used, and to finish the model, plaster of Paris is applied by means of an ordinary house painter's brush in the necessary number of layers to procure the uniform graduation of slope. It is preferable to use "superfine" plaster of Paris for this purpose, and a little dissolved glue added to the liquid will be found to retard it from setting too quickly, and curiously enough its subsequent hardness will be considerably increased. The model, when completed, comprises the necessary elements of strength and rigidity, and is very much lighter and more portable than models built up either with the skeleton pin method, or the process involving the use of veneer. In addition to this the work can be accomplished in probably one hundredth part of the time required for the earlier types of models and the expense is reduced in a similar ratio.

After the relief map has been constructed there still remains the problem of placing upon its surface the necessary coloring and marking to enable the local characteristics to be properly represented. At first sight the process of accurately conveying to the surface of a raised model the necessary surface indications shown in an ordinary survey map would appear to be a matter of some difficulty, but in order to make such a model of any value it is necessary to color the same and mark on it the surface details. To do this the model should first receive a coat of size, and then a distemper wash of light green can be applied. In

Fig. 3.

order to transfer the details accurately, the following method has been found to give the best results. The original map is divided into a number of squares by means of red lines, and the model is then divided into a similar number of squares by means of a white chalk pencil. The position of these squares is first marked on the edges of the board or mount carrying the model. Three deal battens properly squared and planed, of suitable size and length are then procured and arranged as shown in the sketch, Fig. 5, care being taken to see that the top surface of the cross batten is at a dead level, while the end surface of this batten clears

the highest projection of the model underneath. A white chalk pencil is next fitted into a holder constructed of a small squared piece of wood 6 inches to 9 inches long, with a hole bored in it at one end to take the pencil as shown in Fig. 6. The holder is then placed against the side of the cross batten, and the model beneath it is then adjusted so that the point of the pencil comes accurately on one of the marks at the edge of the mount, and also on being moved over, on the corresponding mark on the other side of the mount. When this is done commencement is made on the model by moving the pencil right across the surface and holding it in close conjunction with the side of the cross batten, which is kept square with the longitudinal battens, and free from any lateral movement across them. If necessary, strips of wood can be tacked to the under side of the cross batten for guides on the longitudinal pieces. The pencil, held carefully and not too tightly, will rise and fall with the irregularities of the model, and a true line running up hill and down dale over undulations will in consequence be plainly marked on the surface of the model. The model is then adjusted for a second line, and the process is repeated until the surface is divided up into the necessary number of squares. When the squares have been transferred to the model, the next portion of the process is to copy off the required detail from the original map onto the model. This is most easily effected by obtaining a small piece of transparent celluloid having dimensions slightly larger than the squares on the map. The celluloid is laid down on the map, and a square marked off on it. It will be found that Higgins' blue water-proof ink is the best for the purpose. After the lines are dry, the small piece of celluloid is reversed and laid down on the map so that the marked squares on each exactly correspond. The details, such as roads, houses, fields, woods, rivers, etc., on the map within the square are then traced off on the celluloid in blue ink, and the draughtsman, by taking the square of celluloid in his left hand and holding it close to the corresponding square on the model is able to copy accurately thereon with a soft blacklead pencil or in white chalk all the

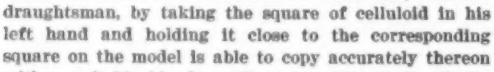


Fig. 4.

details described above. When this has been done a wet sponge or rag will immediately remove all details from the celluloid without harming the square which is on the underside of the celluloid, and a second set of details can then be traced off. The process is repeated until all the squares on the map have been traced and transferred to the model, and when the markings on the latter are completed they can be filled in permanently by means of the necessary inks or colors.

Up to the present the question of obtaining the necessary data for preparing such relief maps has not been dealt with, and this is a most important part of the subject. The levels, distances, and angles are generally obtained by the usual methods of survey adopted in preparing an ordinary mine plan, but occasionally in preparing a contour plan or obtaining the necessary information for constructing a surface model of mining property, it is the case that difficulties of a very trying nature have to be overcome by the surveyor in obtaining the necessary data. In some instances such difficulties make it almost impossible to proceed by the use of the level and staff in the usual manner, and in such cases special means have to be adopted.

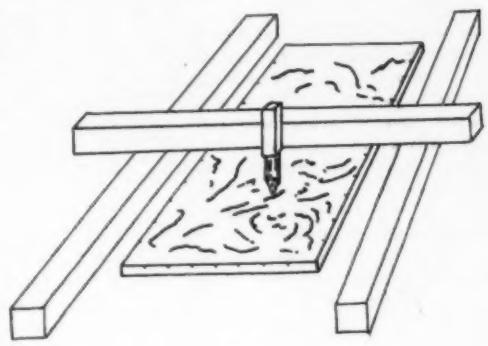


Fig. 5.

A method which was used some time ago by a surveyor in the construction of a model of a china clay pit in connection with a law case, may, therefore, be detailed as follows. The model, which was to be used as evidence of the actual conformation of the pit, had, of course, to be very accurate, both as regards vertical and horizontal scale, and the surveyor had at first proceeded to the pit with the intention of contouring it with five-foot contours. On arrival in position, however, he found that the slope of one side of the pit was almost vertical, and, moreover, its soft and moving substance effectually prevented him from putting up his instrument at more than a very few points along the top terrace and in the bottom of the pit. Moreover, it was found to be quite impossible to climb up the side of the pit referred to. The method adopted was, therefore, as shown in Fig. 7. Four long pegs were driven into the ground at the points marked *A*, *B*, *C*, *D*, in the bottom of the pit. These points were selected as far apart as possible and were so placed as to allow the line from *C* to *D* to cross the line from *A* to *B* at right angles. the distances *A-B*, *C-D* were measured with the utmost care by means of a steel tape, and the surveyor then set up his theodolite at the point *A* and took shots to poles driven into the sides of the pit at frequent intervals, as for example, at *a*, *b*, *c*, *d*, *e*, *f*, *g*, etc. At each shot both the angle and elevation and also the horizontal angle, with reference to line *A-B* was noted and the hypothenuse was also measured. In some places, however, it was impossible to climb up the side of the pit in order to insert the necessary poles in it, and so an assistant was told off to hold up a long pole in the necessary positions. The end of this pole was painted red so that it would show up clearly against the white clay, and the surveyor took the angles, both aximuthal and vertical, from both ends of his base lines *A-B* or *C-D* to the red portion of the pole. It will be seen that this method involved a very large number of observations, and afterward in the office the vertical heights of these temporary red pole point positions were worked out and the five-foot contours were duly inserted by interpolation in the usual way.

From the above notes it will be seen that the preparation of models of this description is not only a most interesting occupation for the mine surveyor, but one which, if properly carried out will very often lead to valuable results in clearing up any points which may be in doubt regarding the working of the mine. For this reason it has been thought advisable to mention the matter somewhat in detail in order to give the necessary hints which will enable the mining surveyor to obtain these relief models in a comparatively simple and easy manner.

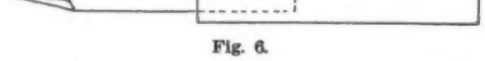


Fig. 6.

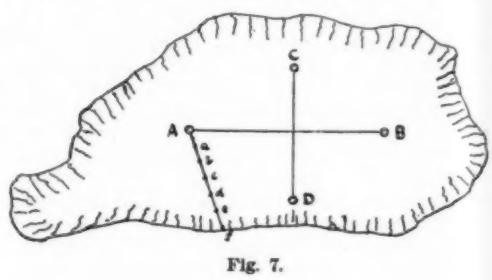


Fig. 7.

The Cleveland Fly Campaign*

A Scientific Battle Against Disease-Carriers

By Jean Dawson

For the past year, Cleveland has been engaged in a campaign that is epoch-making in the history of the city's sanitation. The home, the school and the business world have alike had their eyes focused on the housefly with the spirit that all must work together for the good of the whole.

Although Cleveland has known that the housefly is a carrier of disease ever since the Spanish-American war, until now she has made no concerted effort to rid herself of this dangerous foe. She learned of the great epidemic of typhoid fever that broke out among the soldiers, which killed ten times more men than were slain by Spanish bullets. She was puzzled by the epidemic because she knew that the doctors had examined all drinking water beforehand. Her interest was as keen as the rest of mankind when she learned that suspicion rested on the housefly. She read with disgust that the doctors had found the flies both feeding and breeding in the latrines. Lime had been used to purify these and whitefooted flies were found swarming over the soldiers' food, leaving millions of typhoid germs. Cleveland had reason to remember all this, for she had sent some of her brightest and best sons to share in these ghastly death feasts.

For nearly fifteen years, evidence has been accumulating against the housefly as a carrier of disease. Experts have told Cleveland that at least 33 per cent of her typhoid cases could be traced to the housefly and that this insect was also active in carrying tuberculosis, spinal meningitis, infantile paralysis, and other germinal diseases, yet the physicians of the city have been left to stem the tide of contagion alone. Seemingly it has never occurred to Cleveland that she had responsibilities in the matter; that she should unite her forces and advance against the enemy.

What aroused her at last? It was a little thing, the beginnings of things usually are. The voice of a young girl asking the simple question, "If the housefly is so dangerous to health why don't we get rid of it?" was the magic touch that enlisted the whole community in the fight.

The questioner was a member of the civic biology class in the Cleveland Normal School—time, early spring, 1911. The question was natural enough, yet no member of the class in previous years had so much as thought of asking it. The reason being, presumably, that up to this time the only method generally advocated for reducing the number of flies was directed toward cleaning up their breeding places, which everybody conceded to be the duty of the Board of Health.

Thus it was that Cleveland washed her hands of the whole matter and waited fifteen years for her Board of Health to do the impossible. For while most of our houseflies breed in horse stables, many breed in all sorts of decaying vegetable or animal matter, compost, lawn clippings or garden weeds, and they may even breed from the snuff on the druggist's counter. It was manifest, therefore, that as long as there were any flies about, they could find some material in which to lay their eggs. This meant that no board of health, short of a committee of the whole community could possibly cope with the fly problem.

But, you say, does the city of Cleveland not have laws governing the removal of manure from the stables? To be sure the Board of Health had passed an ordinance, the observance of which is manifestly impossible for the small stablemen and the large ones, even when they do observe the letter of the law, often leave enough manure behind to breed thousands and thousands of flies.

The civic biology class is always eager to get the last word relating to the biological problems of the city: the girl's question was followed by a discussion of an entirely new plan for an anti-fly campaign, as advanced by Prof. Hodge of Clark University. This plan consisted of trapping all flies as they are attracted to food, before they can lay eggs. Dr. Hodge contended that if everyone co-operated, no flies could escape to go back to the stables to lay their eggs, and thus the flies would speedily disappear.

The class was stirred at the possibilities of the plan. The question, "If the housefly is so dangerous to health, why do we not get rid of it?" was asked at the psychological moment, and it bore fruit. Before leaving the laboratory, these young women resolved to try out the Hodge plan by testing the efficiency of outdoor trapping.

The city Board of Health, hearing of their determination, offered to purchase the traps for the experiment. All summer long each of these young women kept a trap baited at her back door and actually counted daily

* This paper was read before the Economic Section of the American Association for the Advancement of Science, at the Cleveland meeting, and was followed by the exhibition of a moving picture depicting the progress of the campaign from its inception in the normal school.

the number of flies caught. In the fall, the results of the experiment were published in the local newspapers. It was the beginning of the Ant-Fly Campaign, of Cleveland.

Early in the year, the Chamber of Commerce, after examining the plans of the campaign, gave it moral support, the mayor appointed a citizens' committee to help; various women's clubs pledged their aid; the Board of Health donated a room in the City Hall for fly headquarters, and soon the work of killing flies was organized, as a city-wide movement.

From the beginning, the idea uppermost in the mind of the committee was to try and unite the entire community, so that we could put forth a supreme effort to rid ourselves of the fly, to do team work, as it were. We went on the assumption that most people will do the right thing if they only know how. To this end, the small pamphlet, "Questions on the Housefly," was published and widely distributed. In all the city schools, both public and parochial, lessons were given on the housefly, as part of their class work. Four daily newspapers and several foreign papers devoted considerable space to the work of the campaign. Many illustrated lectures on the fly were delivered in the city, and for three weeks a motion picture, giving the salient features of the campaign was shown, accompanied by a lecturer, in four of the larger theaters.

Knowing must precede doing. Thus it was that when the winter campaign opened in February, the response of the public was most gratifying. Ten cents a hundred was offered for all flies whether blue bottles, green bottles, stable flies or houseflies. School vied with school for bounty money, with the result that practically every mother fly that came from her hiding place before the middle of May, met with an untimely death. Excitement ran high at this time; the newspapers were very active and did much to further the desired ends.

Darker days, however, were at hand. At the beginning of the summer campaign, a reaction set in which threatened to permanently disable the flyfighters. Owing to the inability of the finance committee to act, we found ourselves about 800 dollars in debt, and with the certainty that we would need at least two thousand dollars in all, to tide ourselves over the summer. Then began the long, hard pull of getting the necessary capital through popular subscription.

Nor was obtaining the necessary funds the greatest of our trouble. To our surprise, we found that the results of our winter campaign were interfering seriously with our plans for the summer. We had hoped to get people interested in trapping flies out-of-doors. It was not to be, however, at least not for some time. Flies were so scarce in many of the residence sections of the city, that people were indifferent to them. "We don't need a trap, we have no flies," was a stereotyped answer when asked to co-operate. Owing to the scarcity of flies, in the early part of the summer, the demand for the traps was so light that few merchants would handle them. To create a demand, the Citizen's Committee bought quantities of the traps from the manufacturers and sold them to the children at wholesale prices. Thus every trap sold by a child netted him a profit of ten cents.

The three months, June, July and August, went by in rapid succession. Every day brought forth its own problems to be met and solved and every hour brought to light a new phase of human nature. We raised the required amount of money, placed thousands of traps into the homes, thus making the merchants glad to handle them and went about giving private instructions on how to get rid of the flies. Conducting the Cleveland Fly Campaign left no room for monotony. From the schoolroom to the vaudeville stage, with frequent plunges into the commercial, professional and newspaper worlds by way of variety and interest. The wealth of pleasurable and profitable experience was worth all the effort expended and ten fold more.

Contact with thousands of people has led to the conviction that the greatest drawback to a successful campaign against the fly is a lack of conviction that the fly is really a carrier of disease and a lack of faith that the fly can ever be exterminated. Way down in their hearts they are reasoning something like this: "Flies there have always been and flies there will always be—one might as well try to control the wind."

Whenever personal contact could be secured, we have found that the following statement about the fly has convinced and borne fruit:

"The scientists the world over now know that the housefly is the most dangerous enemy of mankind. Just how many people are killed in Cleveland by fly-borne diseases is not known and never can be known until we completely rid our city of the pests. We do know this, that only four out of every five children born in Cleveland live to be five years of age. It is a common thing to hear parents remark, "I don't know where my child got that disease. We have been so careful." The chances are that the answer to that parent's query is "flies."

But many will say, "We have no flies in our house." This may be true, but no one is safe from fly-borne diseases so long as our dairies, markets and provision stores are swarming with flies.

The Anti-Fly Campaign was inaugurated in Cleveland to do away with all this sickness and death. That it can be done is shown by the work in Panama. France failed at Panama because so many thousands of her men lost their lives through disease. This country has succeeded because we have practically rid the Canal Zone of mosquitoes and flies. To-day Panama is safer to live in than any city in the United States. We can make Cleveland equally safe, if we will do four things:

1. Kill all the flies that survive the winter, as soon as they appear in the spring. These are the mother flies, few in number, but responsible for all the generations that infest the summer. One fly killed at this season is equal to killing millions in August or September.

2. Be sure that no flies either feed or breed on our premises. This must be our universal rule, for even in the best of homes we have records of garbage cans that have neither top nor bottom.

3. We need to have some kind of a fly trap set in our back yards, so as to catch all the flies on their way from their breeding places to our homes.

4. Realizing the dangers of the housefly, we must cease to trade with dealers who permit flies to swarm in our dairies, restaurants, markets and bakeries. By withdrawing patronage from the careless dealer, we can put our fly campaign on a dollar and cent basis. This will line up all dealers in food stuffs on the defensive. They will in turn demand that all places where flies may breed in their neighborhood be cleaned up. Then we will have not only a flyless but a really clean Cleveland.

Did the people respond to such teaching, you ask? Did we get tangible results? Was the campaign a success? A small volume might be written in answer to these questions, instead of the brief space left. Perhaps the best means of judging the degree of success or failure of a movement of this nature is to get the attitude of the commercial world. Good business men are keenly alive to the slightest change in the public pulse and act accordingly. To illustrate: When we went to the aid of the proprietor of a large, down-town restaurant this summer, the man made this very significant statement: "You see, since the city has been so stirred up about flies, we can't afford to have them about. It was only yesterday that an old gentleman, for years one of my best customers, told me how they hated flies in his home. He said that he and his wife would chase a fly all day and wouldn't rest until they had killed it. Now you know, the keeper of this restaurant added, I can't hope to keep a customer like that if I have flies about."

Strange as it may seem, the business world held out a helping hand far more eagerly than the domestic world, indeed, the average man seemed to attach far more importance to the control of the housefly than the average woman.

We are encouraged to do battle afresh when we hear words of appreciation such as were given by a member of a delicatessen firm, whose name in Cleveland is synonomous with quality. "You will never know the amount of good the Anti-Fly Campaign has done for this city. All summer our down-town store has had no more flies than during the winter months, and I have noticed restaurants and meat markets that are as free from flies as we are."

The amount of typhoid fever has been greatly reduced in Cleveland during the summer. Perhaps, the reduction, at least in part, is due to war on the fly: all open vaults were screened and bushels of flies were trapped and killed in the markets and provision houses.

By far the weakest feature in the campaign was the lack of support from the city's Department of Sanitation. Before the campaign was well started, the calls from the people to rectify unsanitary conditions were so numerous that the small number of sanitary policemen was found wholly inadequate. The following is a case in point: By co-operating with the fly fighters the proprietor of an outlying restaurant set out to keep his establishment as free from flies as he did from other dirt and filth. His next door neighbor kept a meat market at the back of which he killed dozens of chickens every week. The scalded feathers were dumped into an open barrel and allowed to stand for days until the maggots were large sized. The stench from the feathers brought all the flies in the neighborhood to the screen doors of the restaurant. The oft repeated complaints sent to the City Hall were without results and this man, in spite of his best efforts, was compelled to do business in a fly infested restaurant.

It is obvious that if we are to produce a clean, flyless city, efforts such as this restaurant keeper put forth should not be thwarted and allowed to become futile. The man's experience suggests lines that may be worked with profit in the campaign of 1913.

That there will be a campaign in 1913 seems to be a foregone conclusion. A large ice cream firm has already ordered 300,000 fly swatters to be given away next spring, and children in the manual training classes in the public schools are preparing to make flytraps for their back yards.

Future campaigns will probably be built upon the foundation that already has been laid. Certain it is that with the means now at hand, any community may become flyless by securing the co-operation of its people. In attempting to weld the efforts of a community together, the school and the motion picture theater are factors, which must not be overlooked. The magazine and the newspaper each have its clientele and their influence no one will attempt to deny. Neither, however, can reach the lower masses of humanity, which are so necessary to influence in bringing about a clean, flyless city. Pictures speak to the members of even the lowest dregs of society. The great difficulty is to make a film that will teach its lesson and at the same time be amusing enough to hold its place on a vaudeville programme.

Infinite possibilities lie in interesting the school children in a campaign against the fly. First, because the schools reach all classes of people, and second, because of the great funds of undirected energy of youth that may be utilized for the good of the community.

Medical Men as Geologists

IT is a curious fact that many of the most important medical discoveries were made in the first instance by non-medical investigators, and that medical men, on the other hand, have often been leaders in arts and sciences remote from their own. If there is any department of pure science in which we should expect physicians to take a minimum of interest, it is that of geology. Yet it is precisely in this field that we find them doing some of the most brilliant and effective work. The "Airs, Waters, and Places" of Hippocrates is indeed the first scientific study of the terrain or lay of the land, so important in the selection of sites for cities, dwellings, camps, and hospitals. Theophrastus founded petrography (*De lapidibus*). Avicenna was, however, the pioneer geologist, and his wonderful description of the formation of mountains has been justly praised by Draper[1] and others as worthy to be in any modern textbook. Fracastorius was, with Leonardo da Vinci, the first to see fossils[2] as animal remains instead of products of special creation or of astral influence. Descartes first stated the nebular or "molten magma" theory of the earth's formation. Stenson (of Steno's duct) discovered that the glossopetræ found in north Italian rocks were fossil teeth of the shark or dogfish tribe and his "De solido intra solidum" (1669) lays down the fundamental laws of stratigraphy. In 1881 a bust over his tomb was unveiled[3] by the geologists of all nations. John Hunter's paper, "On Extraneous Fossils," set forth the important view that they are coeval with the strata in which they are found. The Huttonian theory of the formation of the earth's crust was stated by a physician, James Hutton, in 1795. Wollaston, famous for his early analyses of urinary calculi, is also remembered by wollastonite and the Wollaston medal awarded by the Geological Society of London. Cuvier and Lamarck, the founders of vertebrate and invertebrate paleontology, respectively, as well as Agassiz, were physicians. Sir Richard Owen wrote thousands of pages on the extinct reptiles, mammals, and birds of Great Britain and Australia. Karl Vogt was a geologist, Johannes Müller a paleontologist, and von Baer devoted the latter half of his life to working up the physiography of the Russian Empire. Samuel G. Morton's book on fossil remains (1834) was the starting point of all American studies, and Leidy was one of our ablest paleontologists. Three eminent English clinicians, Bright,[4] Murchison, and Parkinson,[5] were also enthusiastic geologists, the last one of the leading authorities on fossil remains, and Huxley's brilliant researches on fossil fishes and crocodiles, on the ancestry of the horse, and on geological time are by no means the least of his titles to scientific fame.—*New York Medical Journal.*

[1] See Draper, "Intellectual Development of Europe," I, pp. 410-411.

[2] Taken from rocks employed in building the citadel of San Felice, Verona, in 1517.

[3] In the Basilica of San Lorenzo at Florence.

[4] Bright investigated the geological strata around Bristol in 1811 and in Hungary in 1818.

[5] For an account of Parkinson's work, see *Johns Hopkins Hospital Bulletin*, xxiii, 39, 1912.

The Claude Process for Reproducing Drawings

By the Paris Correspondent of the Scientific American

In the new Claude process which is brought out by a Paris inventor for reproducing drawings, the prints are obtained from gelatine surfaces at a greatly increased speed. The "graphitic" process, as it is called, is based on the curious property possessed by a gelatine preparation which contains an iron salt. This will retain a fatty ink on all the portions where a special ferro-prussiate paper applied to the surface has not been acted on by light.

The outfit for this purpose is a simple one, consisting of a flat table having a binged or tilting plate, this latter being covered on the top by a sheet of commercial zinc; a water-bath for use in melting the gelatine, an ink roller with its plate, etc. The gelatine preparation is melted in the water-bath at a temperature of about 55 deg. Cent. When using, it is poured through a fine sieve to remove impurities. To prepare a plate, the zinc sheet is inclined at 35 or 40 degrees and the gelatine is poured upon the upper part so as to run over the plate and cover it, the excess running into a trough at the lower part. When the plate is well covered it is lowered to the flat position and is left to cool, which takes 5 or 10 minutes. The thickness of the gelatine adhering to the zinc plate should not be more than 0.06 inch. During this time a print has been made from a tracing, upon a special ferro-prussiate paper, and without washing the print it is applied on the gelatine plate, rubbing slightly with the hand to avoid air bubbles. It is then removed without leaving it on too long. In this way the drawing appears in dull lines upon a polished ground. The ink roller is then passed over the surface and the lines of the drawing appear at once in black or any other color which may have been chosen for the ink. The paper is then laid upon the plate and is pressed on and flattened by the hand so as to receive the ink and thus make a print in black or colored lines upon the paper. Then the paper is removed and the plate is re-inked with the roller in order to apply a fresh sheet and so on. One point is to be noted which is likely to make the process a valuable one. Before putting the print made on the ferro-prussiate paper upon the plate, it is possible to add, suppress or modify in any way the drawing which is to be finally printed, and this is done by placing strips of gummed paper on the ferro-prussiate print so as to suppress the lines and prevent them from touching the gelatine. The drawing can thus be connected very readily for lines or figures. To add any parts to the drawing, this is done by making small extra prints upon pieces of ferro-prussiate paper and pasting them on the principal drawing, or else these can be applied upon the gelatine surface after the main sheet has been removed. Several small drawings can be applied at the same time upon the large gelatine surface, if desired, or any kind of combinations made which can be readily imagined. After passing the ink roller over the gelatine, the lines become visible in black or in color, and at this time any needed changes in the drawing can be made, such as removing spots or folds in the original, or erasing, by using a fine wet sponge. When the drawing is finally correct it is inked again by the roller and is ready for the printing on the paper sheets as above noted. As to the printing of the sheets, this is done in a very short time. To dry the ink on the paper quickly, this can be done by sprinkling powdered talc upon it. Prints in several colors can also be made by using a separate tracing for each color. The prints for the blacks are first made and then the gelatine is removed and replaced so as to make the prints for the reds and so on, or each color can have a separate gelatine plate, superposing as for lithographs. When the work with a gelatine plate is finished in any case, the gelatine is scraped off and is ready to be cleaned off, remelted and applied again to the plate. To avoid loss of time, the flowing of the gelatine is best done on one plate while the work is going on with a second plate. The ink remaining on the gelatine after using is removed by drawing off the last print with a quick movement or rolling rapidly with a clean ink roller, or by washing off with water.

Reproduction by the Claude Process of a Larger Drawing of a Building.

Interior View Reproduced by the Claude Process from a Much Larger Drawing.

The World's Greatest Cable Tested

It took a pull of 364 tons to break the largest hoisting cable in the world when sections were tested early in December in the 800,000-pound testing machine of the Fritz Engineering Laboratory at Lehigh University, South Bethlehem, Pa. The tests were conducted in the presence of representatives of the John A. Roebling's Sons Company, manufacturer of the cable, and of the Spanish-American Iron Company, which has been using the rope in the Pennsylvania Steel Company's Mayari mines in Cuba. Three tests were made, all highly satisfactory. A portion of the cable that had been in use for a year and a half withstood a pull of nearly 300 tons.

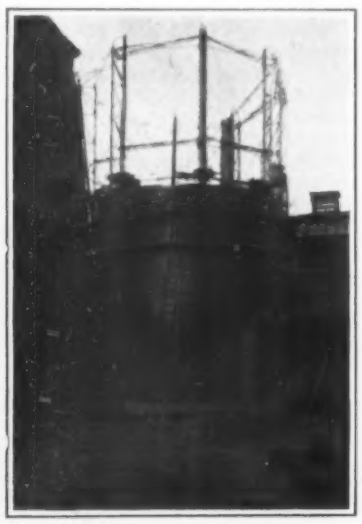
The construction of this cable was without precedent in rope-making. It consists of six strands, each of 19 wires, twisted around an independent wire rope center, this center having six strands of 19 wires each, twisted around a hemp core. The finished cable was 7,810 feet long and weighed 125,360 pounds. Cars with a capacity of 100,000 pounds of ore are lowered by means of this cable down an incline plane 5,800 feet long. Recently it was decided to ascertain the strength of the rope after its year and a half of service, as compared with the strength of portions not worn, and three pieces from the main cable, each about 20 feet in length, were shipped to the Roebling works at Trenton, N. J. There special yokes were placed on the ends to make possible the tests in the giant machine at Lehigh University.—*The Iron Age.*

The Harlé Steam Reservoir

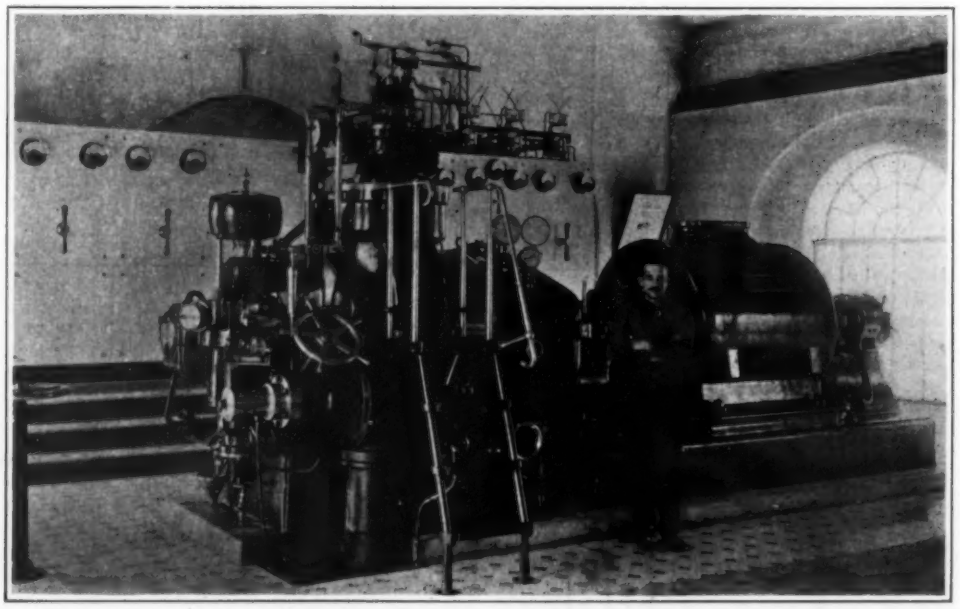
Where a high-pressure engine works continuously there is little difficulty in turning to account the exhaust steam in subsidiary engines. In many types of plant, however, such as rolling mills, the engines work intermittently, and in these cases the utilization of the exhaust steam presents a more difficult problem. One solution, which is finding a widening application, is to lead the steam into a reservoir built and functioning on the principle of the gasometer, and to draw from this reservoir according to requirements for the working of subsidiary engines. The apparatus requires little description, as its general principle is quite familiar to all from the ubiquitous gasometer. It consists of an inverted bell-tank, its open mouth at the bottom dipping into a liquid seal. The bell is covered with non-conducting material to reduce heat losses to a minimum, and is balanced in the usual way. The general appearance of the reservoir is shown in one of our illustrations, from which its close similarity to a gasometer will be recognized. Our second illustration shows a low-pressure turbine fed from such a gas holder. This is a 540 horse-power machine working at 3,000 revolutions per minute, and fed with steam at one fifth of an atmosphere above atmospheric pressure. This turbine is coupled to a 370-kilowatt, 3,000-volt, 50-cycle alternator.

The steam holder rises and falls with the fluctuations in the amount of steam fed to and drawn from it. The size of the holder is so designed as to ensure that the supply is always equal to the demand.

The steam holder is made in Paris, but has acquired considerable popularity in Germany, where no less than fifteen plants—mostly at mines—are equipped with it.



A Gasometer for Steam.



Low-pressure Turbine (540 Horse-power) Fed From a Steam Holder Receiving Exhaust Steam.

Power from Kerosene

A System Whereby Oil, Kerosene and Distillates Are Used in the Ordinary Type of Gas Engine

By L. W. Ellis and W. R. Dray

THE internal-combustion engine is the most rapidly developing source of power in the world to-day, and will assume increasing importance in the future.

The intelligent public has been slow to adopt the oil engine. It has been educated by use to internal-combustion engines which make an explosive gas out of cold gasoline. Through its familiarity with the automobile, it has come to demand an oil engine that follows established gas-engine practice. Probably the greatest single factor in such distinction as John A. Secor has earned is his early formulation of the *doctrine* that the oil engine need not and must not vary in principle from the gas engine. Second only to that, however, ranks his discovery of the *means* for using oil without sacrificing a single desirable feature of the best gas engines. His work, which is just beginning to have world-wide recognition, offers an answer to the general demand.

Of crude oil as produced in the United States about 15 per cent belongs to the naphtha family. The automobilist, the motor boat owner, the painter, and various artisans each take a portion, leaving practically none for general power purposes. About 35 per cent of the oil belongs to the kerosene family, including power distillates, kerosene and the like. About 15 per cent more is contained in the asphalt and paraffin bases, leaving 35 per cent for the fuel oil family, of which the railroads already use more than one half. The kerosene family is therefore the largest, and will always be so. It will always have a wider distribution than any other. The new system is important because it makes possible the use of this kerosene group and some crude oils in the same way that an automobile handles gasoline, thus greatly simplifying the use of cheaper, heavier oils by the auto-wise operator.

The inventor gave us, over fourteen years ago, a practical oil-burning engine of the standard gas-engine type. This was over thirteen years after he had conceived the idea of an internal-combustion engine adapted to every power need; an engine that could use any liquid or gaseous fuel whatever, from alcohol to crude oil; one that especially could be operated easily, flexibly and with certainty on oil at all speeds, all loads, all altitudes, all conditions of temperature and humidity; and one that would have automatically a finer regulation than the average high-class steam engine.

The Secor patents do not apply to engines which differ from the familiar gas engine type, such as the Diesel and the vaporizing type, nor to the type using the hit-and-miss governor. They are applicable to the throttle-governed engine only. On any throttle-governed engine the governor swings to meet any variation in the load with an accuracy impossible to the human expert. When in proper order it never makes a mistake. For a given load it always takes a certain stand, and delivers a definite quantity of fuel mixture. Secor makes the governor, in addition to its usual duties, do the work of the expert engineer, for to the governor he delegates also the work of regulating the ratio of the fuel to the other portions of the mixture. The Higgins carbureter which is now used in connection with the Secor system, charges the air passing through it with just the proportion of fuel needed to get the best efficiency at light loads, and the most power at heavy loads. When loads are reached that demand the use of water, the governor causes the carbureter to add water to the mixture in the exact proportions needed to control the temperature of vaporization and combustion.

Stated in brief terms, the system covers, (1) an automatic variation in the quantity of fuel mixture in accordance with the slightest variation in speed and load; (2) a degree of compression dependent upon the quantity of the mixture inhaled; (3) a correct proportioning of the mixture under all conditions, involving relatively weaker mixtures for the higher compressions and increasingly stronger mixtures for the lower compressions; (4) a temperature of combustion exactly adapted to the quality of fuel used and the compression; (5) automatic control of the internal temperature through the admission of water as a part of the fuel mixture; (6) thorough and uniform mixture of the fuel, water and air charge by mechanical means and without the application of additional heat; (7) automatic variation in the time of firing in response to variations in the speed and power; (8) means for changing the limits of rotative speed within which all factors are simultaneously controlled; (9) and means for starting on a limited supply of volatile fuel—all of which factors are vital to the control of internal heat, the transformation of heat into power, and power production. These features are now embodied in commercially successful engines which have been adapted to a great variety of stationary and traction work.

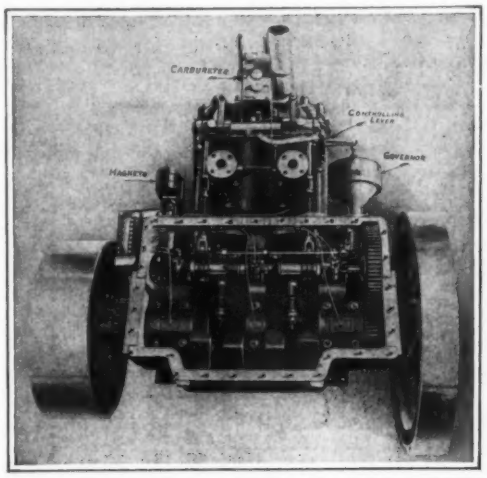


Fig. 1.—Top View of Two-cylinder Motor Equipped With the Automatic Control System.

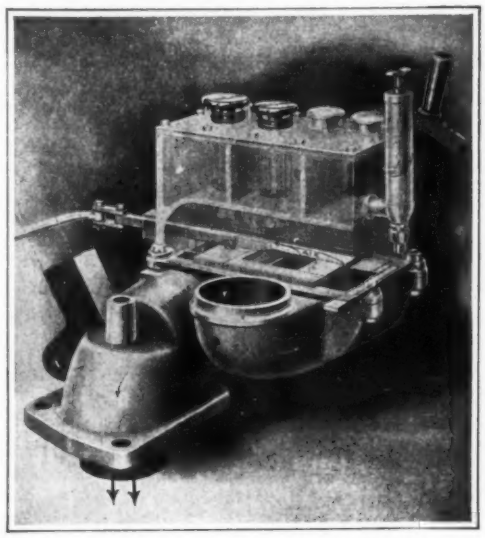


Fig. 2.—The Carbureter, Showing Air Intake and Manifold.

The adaptability of the system here described to the lower grade oils is secured through its providing a coordination of all factors at all times, this being necessary to the more difficult vaporization and combustion of the less volatile oils. The throttling governor, taking a different quantity of fuel mixture for each cycle as the load varies, naturally produces a varying compression within the cylinder. It is well known that at higher compression leaner fuel mixtures may be, and should be used, and *vice versa*. One great factor in the success of the system is that through the mechanism of the special carbureter, the proportions of fuel, air and water are automatically varied in relation to each other as the compression changes. By this means the conditions within the cylinder, whether the engine is run at heavy load or light, are constant so far as they affect the completeness of combustion. Complete combustion eliminates the deposit of carbon which has been regarded as an insurmountable objection to the use of heavy fuels, and the unified automatic control results in the securing of splendid regulation.

The automatic control of the quantity of water is an original feature of the system, and is advantageous for several reasons. In the first place it makes for clean combustion by controlling the temperature of vaporization and combustion so that there is practically no cracking of the low-grade oil with its attendant carbon deposit. The use of water allows the use of higher compression, consequently greater power from the same bore, stroke and speed. The effect of the water in producing a slower-burning mixture is seen in a lower explosion pressure and a fatter indicator card. This results in as high a mean effective pressure as is found in gasoline engines of similar proportions, without the strain and instability produced by a violent initial shock.

There is further, undoubtedly, a dissociation of water into nascent hydrogen and oxygen. The latter, being much more active than the diluted oxygen of the atmosphere, has naturally a greater affinity for any free carbon that may have been deposited at the moment of explosion. The hydrogen set free probably burns with the oxygen of the air as the temperature falls toward the end of the stroke, but it is doubtful whether enough steam is thus formed to exert any considerable expansive effect upon the piston. The process does, however, effectively scour the cylinder. The explosion is converted into a long steady push instead of a short, sharp blow, and the water apparently gives an increase of power of at least 15 per cent over a similar engine without it.

The water is not only controlled as to amount, but is brought into play automatically. As the load increases, the throttle opens and more air is sucked through the carbureter. Not until about half load is reached does the suction become strong enough to lift the water, hence it is not present to hinder ignition at light loads, nor to allow pre-ignition at any time, being neither too heavy for ignition at heavy loads nor too light to control the temperature of vaporization.

Crank shaft, cam shaft, governor, magneto, carbureter, valves and piston act as a positively controlled unit in engines equipped with the new system, hence no one

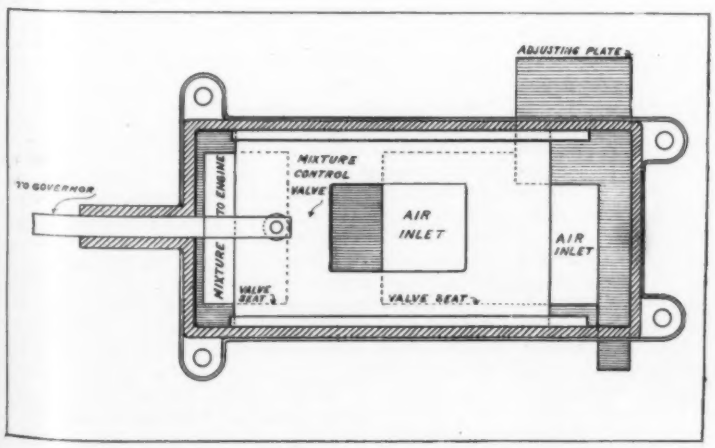


Fig. 3.—Position of Sliding Valve at Light Load.

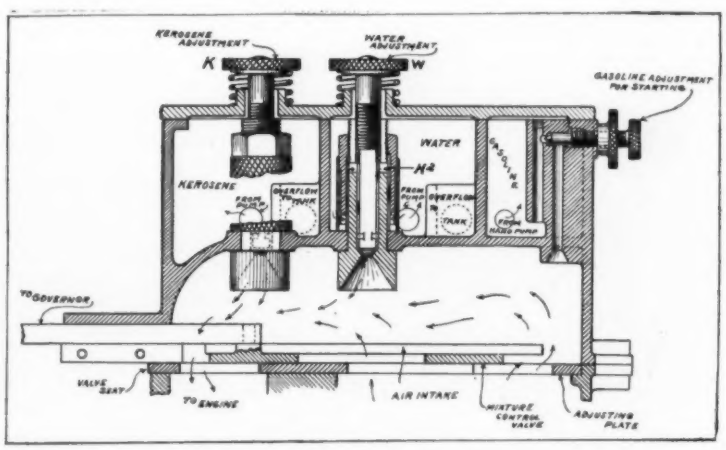


Fig. 4.—Longitudinal Section of Carbureter.

mechanical factor deserves to be set apart from the others in importance. However, the special carbureter, which makes possible the application of the new system, is of sufficient novelty to warrant especial attention. Fig. 1 shows the top view of a two-cylinder tractor motor equipped with the system in question. The cam shaft is gear driven and in turn drives both governor and magneto through bevel gears. The fly-ball governor, through a first-class lever and a link coupling, operates a sliding brass valve which is clearly shown in Fig. 2. The carbureter sits above the cylinders, with the short inlet manifold presenting little opportunity for the mixture to stratify before it is completely vaporized. It contains constant-level chambers for kerosene and water, an overflow being provided for each. It has also, for starting purposes, a chamber for gasoline which is filled by hand pump. This chamber, which holds about a pint, is connected by a siphon with the mixing chamber. Turning the engine over creates suction enough to draw upon the contents of this chamber, but a vent is provided so that if a start is not made immediately the siphon will not continue to act and drain the chamber.

Fig. 3 shows the position of the valve plate at light load. Two air inlets are then open, providing a large ratio of admission to outlet area and thus greatly reducing the relative vacuum in the mixing chamber. As the load increases, the governor throws the sliding valve forward, increasing the area of the outlet to the cylinder, increasing the air inlet in the middle, and decreasing or entirely closing the air opening at the right. Thus the ratio of admission to outlet area decreases, the relative vacuum becomes greater, and more fuel in quantity, though not in proportion, is picked up by the incoming air and carried to the cylinder.

A sectional view from the side (Fig. 4) shows the arrangement of the kerosene and water needle valves, the overflow, etc. It will be noted that the water level is lower than the kerosene level. The suction therefore is not great enough, until the engine reaches about half load, to lift the water to the point (H2) where it can flow down the tube surrounding the needle valve. From half to full load, the ratio of water to fuel increases rapidly until the amounts of fuel and water used are practically equal.

The carbureter is so designed that the fuel needle-valve (*K*) should be adjusted at the full-load position, when the plate is farthest to the right. This order of procedure is important, since at this position the adjustable plate has no effect upon the area of the air inlet openings. The adjustment of the air should be made at the "no-load" position and after once made, need never be changed, unless the engine enters a very different altitude. This adjustable plate allows each carbureter to be adjusted to the engine it is to serve, hence the slight variations in manufacturing are fully taken care of. The sliding plate is the only moving part in the carbureter, and that is positively controlled. There are no springs, floats, or check valves. Wear cannot affect the size of the air openings which control the relative vacuum in the mixing chamber, therefore the accuracy of the carbureter will never be interfered with by any ordinary cause.

Ignition is necessarily electric, and in large engines where the speed variation is great, means have been developed for automatically advancing the spark as the speed increases. On ordinary engines, however, only such manual adjustments are needed or provided as will take care of the starting and normal speeds.

One of the most noted gas-engine builders in the country has adapted this system to a line of stationary kerosene and distillate engines which will eventually range in size from 50 to 170 horse-power. His factory tests show an efficiency of over 15 brake horse-power hours per gallon of kerosene on 50 horse-power single cylinder engines at all loads from about one third to shortly below the maximum. The manufacturer's literature places a guarantee of within 2 per cent on speed regulation. One other large licensee making stationary engines in sizes from 3 to 15 horse-power is achieving considerable success through a series of electric lighting and power outfits suitable for the country home or small business. The generators are direct-connected, yet give steadier power than the average public service in the smaller towns. The U. S. Government is using a number of engines fitted with this system to drive air compressors for foghorns in life-saving stations on the Great Lakes.

A six-cylinder marine engine using the system here described develops a brake horse-power hour from 0.9 pint of kerosene. A large number of these engines are being used by the Japanese government for operating electric lighting and wireless telegraph stations, and these engines have been adapted to a great variety of uses in this country where safety and close speed regulation are essentials. Naturally, insurance rates are much lower where a non-volatile fuel is used.

The widest use of this system, however, has been made in connection with farm tractors. One factory built more than 50 tractors a week as an average for the year 1912 with a total of more than 115,000 horse-power. These engines are meeting with universal success, operating on the kerosene and distillates of the United States, on gasoline in South America, and on the lighter grades of crude oil found in the United States and Southern Russia. One tractor recently ran for four months on Montana crude oil without cleaning or even inspection. A two-cylinder tractor, 10-inch bore by 12-inch stroke, running at 375 revolutions per minute, recently developed in an official contest at Winnipeg, Manitoba, 51 brake horse-power in an economy test with a consumption of 0.71 pound of fuel per horse-power hour, and 76.5 horse-power in a maximum test on 0.85 pound of fuel. This is a grade of fuel which sells at 5½ to 7 cents in barrel lots in country towns throughout the Central States, and weighs nearly 7 pounds to the United States gallon.

In the Winnipeg Motor Contest of 1911, a single-cylinder engine of the same type averaged 0.85 of a pint of fuel per brake horse-power hour on kerosene and 0.93 of a pint per brake horse-power hour on gasoline. The kerosene contained 16 to 20 per cent more heat units than gasoline, hence the engine running on kerosene, while a trifle more economical as regards volume of fuel used, was a trifle less efficient thermally. In the last three such competitions, the fuel cost of the tractors operated under these patents has been consistently lowered and has remained at or near the lowest point recorded, while the speed regulation has been scored perfect in nearly every instance. The recent winning of a gold medal and sweepstakes over more than 20 other tractors, including 4 steam and 14 gasoline, indicates that the desirable oil-burning feature has been achieved without sacrificing any points of excellence. These tractors are being used by ordinary farm hands in every condition of climate and altitude without further adjustment than is provided for in the simple carbureter.

The owners of the patents are proceeding carefully in their efforts to adapt the new system to a wide variety of popular power uses. No serious attempt has been made as yet to adapt it to automobile or motor truck use, and the marine engines referred to are of the heavy-duty type designed more particularly for coastwise trade. The farm market has so far occupied the attention of the manufacturers to the practical exclusion of all others, but strong efforts are now being put forth to occupy the irrigation and cotton gin fields. The rice fields of Louisiana and Texas are taking a large number of these motors, and they are becoming popular in western mining districts.

The new system is the result of one man's close attention for the last 28 years to the problem of burning oil without in the least changing the essentials of the most popular type of internal combustion engine. For nearly 15 years practicable engines embodying the system have been on the market, but the perfection of the present form of carbureter gave the method a decided impetus. Basic patents have invited the investment of capital by a number of manufacturing concerns and three are now marketing engines that with three-cent fuel are capable of supplying power at a fuel cost of one third of a cent or less per horse-power per hour. The system has been applied to both two-cycle and four-cycle engines, and to engines running above 1,100 revolutions per minute.

With the production of kerosene out-running that of motor gasoline nearly four to one, the world-wide introduction of this process comes at an opportune time.

While this article was being written, not many weeks ago, a tramp steamer from Singapore was discharging a cargo of gasoline at Montreal. The prevailing state of affairs, even in oil-producing countries, is indicated by the fact that the Russian government has recently offered a bounty for the production of industrial alcohol to supplement the gasoline supply. However, the problem of burning oil in a gas engine—one that has been in the minds of engineers for the last 20 years—seems to have been finally and satisfactorily solved.

The Significance of Spectroscopy for the Atomistic Theory*

A Rational Theory Wanted to Correlate Observed Facts

By Prof. C. Runge

Although Bunsen and Kirchhoff employed the term spectrum analysis in the narrow sense of "chemical analysis by means of spectra" they should be regarded as the founders of the whole modern science of spectroscopy, for they appreciated the significance of the fundamental facts—that atoms and molecules are vibratory systems and that their periods of vibration are indicated by the variously colored rays emitted by glowing vapors.

In Bunsen's words, these periods "condition chemical characters as constant and fundamental as atomic weight, and they can be measured with almost astronomical precision." The qualification "almost" can now be omitted, for the periods of the cadmium lines whose wave-lengths have been compared with the standard meter by Michelson are known to less than one millionth of their value.

A relation between the periods of vibration and the other properties of an element, analogous to the relation between the musical tones emitted by a vibrating body and its mass, form and elasticity, must have suggested itself to the founders of spectrum analysis, although they gave no expression to this idea, probably because the spectra which they observed showed no trace of order or regularity.

At first glance, indeed, the spectra of the elements appear utterly irregular, and some of them are so complex that the task of reducing them to law and order seems hopeless. An example is the spectrum of iron, in which Kayser and I have measured more than 4,000 lines. Stoney, in 1870, first discovered a semblance of order, although he failed to find, as he expected, simple numerical relations among the spectral lines of an element, analogous to the relations that connect the overtones of a musical note. He did find that three of the four strong hydrogen lines have vibration-frequencies proportional to the whole numbers 20, 27 and 32, but this discovery bore no fruit until Balmer, in 1885, discovered the true mathematical form of the relation. According to this law, the vibration-frequencies of the hydrogen lines are proportional to the expression $1 - \frac{4}{n^2}$ in which the whole numbers 3, 4, 5, etc., are successively substituted for n. The ratio 20:27:32, is obtained by making n equal successively to 3, 4 and 6, and all other hydrogen lines can be found by substituting other whole numbers for n. The formula gives the vibration-frequencies of the 29 hydrogen lines now known, to within one part in 100,000.

In the search for analogous laws applicable to the spectra of other elements it was found that the essential property common to such spectra is not a simple numerical relation among vibration-frequencies but the probable existence of an infinite series of frequencies, gradually approaching a finite limit, with steadily diminishing intensity. Such series of lines are found in many spectra and, in numerous instances, the law of formation of the series has been discovered and an apparently chaotic spectrum has been resolved into a number of superimposed, regular series of lines. The spectrum of helium, for example, contains eight such series. The complete helium spectrum is represented in the uppermost section of Fig. 1, and the component series are shown separately in the other sections. The regular arrangements of the lines in each series is apparent at a glance, but the regular progressive diminution in intensity with increase in vibration-frequency, in going toward the right or violet end, is not well shown in the drawing. The eight series of lines may be divided into two groups, each comprising four series, connected by relations which can be shown more effectively by comparing the spectra of the alkali metals, each of which is composed of four series of lines.

The spectra of the alkali metals are illustrated in Fig. 2. The first four sections, beginning at the top, represent the component series of the lithium spectrum. The remaining groups of four sections represent the component series of sodium, potassium, rubidium and cæsium. All five spectra are found in exactly the same way, so that every line of each spectrum corresponds to a line in each of the other four spectra. All of the lines shown in the figure (except those of lithium, which are still in doubt) are resolved into double lines by increasing the dispersion. Bunsen and Kirchhoff observed many of the lines here shown, but they failed to detect the relations among the various spectra, because they did not know the law of formation of the individual spectra. For example, the dark red double line to which rubidium owes its name corresponds, in the cæsium spectrum, to a double line in the ultra-red which is invisible, although

* Translated from *Zeitschrift für Elektrochemie.*

its energy exceeds that of all other cæsium lines. Hence Bunsen and Kirchhoff regarded the next line of the series, which falls in the blue, as the principal line of cæsium, and named the element accordingly. In the sodium only the double line and the yellow was known to Bunsen and Kirchhoff. The next line of this series lies in the ultra-violet, but forty-eight lines of the series have been photographed, with the aid of quartz prisms, by Wood, who expresses the conviction that an indefinitely great number of lines of still higher refrangibility can be discovered if the pressure of the sodium vapor and the dispersive power of the apparatus can be sufficiently increased.

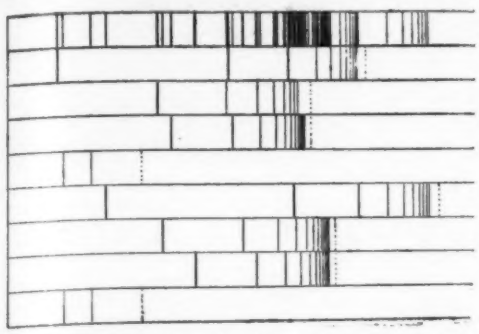


Fig. 1.—The Spectrum of Helium and Its Eight Component Series.

In order to show the relations which connect the four series of each spectrum I have drawn, in Fig. 3, the four series of the cæsium spectrum in such a way that their upper limits, at the violet or right end, coincide. The origin, or zero point, of the first series is at the left end of the uppermost section of the drawing. The second and third series, like the first, consist of double lines, whose origins coincide with the lines of the first pair of the first series. The origin of the fourth series coincides with the first line of the third series. Hence the interval between the lines of each pair in the second and third series is equal to the interval between the lines of the first pair in the first series. This constant difference in vibration-frequency between paired lines, which is observed in many spectra, is so exact that, despite the great and ever-increasing precision of spectroscopic measurements, the apparent deviations from constancy still lie within the limits of errors of observation. In the spectra of mercury, thallium and many other elements, the intervals in question are so large that they can be determined within 1/30,000 of their amount. Even these spectra show no deviation from the law of constant difference in the vibration-frequencies of paired lines. Many spectra show lines which have vibration-frequencies equal to the differences between the frequencies of other lines belonging to different series—for example, between the second pair of the first cæsium series (Fig. 3) and both the first and second pairs of the second series. It is not improbable that every interval between two lines is represented by another line, and that only the strongest of these lines have been discovered.

These laws of formation are repeated in the spectrum of each member of a group of chemically related elements, with modifications that are evidently dependent upon the atomic weight. For example, an inspection of Fig. 2 shows that the limits of corresponding series move toward the left or red end. i. e., in the direction of slower vibration, as the atomic weight increases. This rule does not apply to analogous individual lines, such as the red lithium line and the yellow sodium line, because the series contract and therefore shift some lines toward the right, as the atomic weight increases. This effect is shown more clearly in Fig. 4 which includes only the series of each spectrum which contains the principal line of the element. The spectral lines are indicated by small circles and the

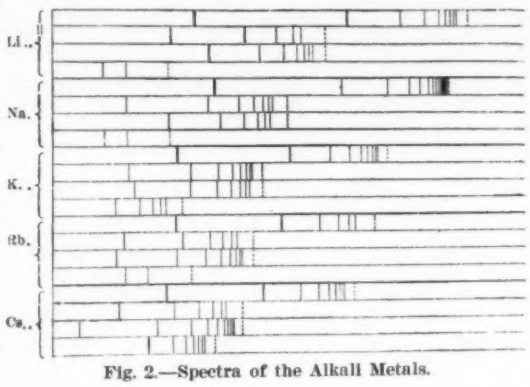


Fig. 2.—Spectra of the Alkali Metals.

five series are so drawn that their limits coincide, and the distance of each below the top of the drawing is proportional to the atomic weight. The series contract rapidly in going from lithium through sodium to potassium, and more slowly in going from potassium through rubidium to cæsium.

The connection between the atomic weight and the interval which separates the components of double lines is equally evident, except in the case of lithium, where it is yet uncertain whether the lines are doubled or not.

Fig. 5 shows a representative pair of lines of each of the other alkali metals, sodium, potassium, rubidium and cæsium. The horizontal distance between the lines of each pair represents the difference in vibration-frequency, and the vertical distances between lines of different elements represent differences in atomic weight. The interval, or difference in vibration-frequency, between the lines of a pair is approximately proportional to the square of the atomic weight, in the group of alkali-metals, and to the other powers of the atomic weight in other groups of elements. This law can be illustrated graphically by plotting the logarithms of the intervals as abscissæ and the logarithms of the atomic weights as ordinates. If the pair-interval were exactly proportional to a power of the atomic weight the plotted points would lie precisely in a straight line. How nearly they do so in the case of the alkaline-earth-metals is shown in Fig. 6. If the proportionality were exact it would furnish by far the most accurate method of determining atomic weights, but as it is only approximate, it may lead to serious error, especially when extrapolation is required, as is shown in Fig. 6 by the discrepancy between Mme. Curie's value of the atomic weight of radium and the value obtained by graphical extrapolation. On the other hand, it is evident from the figure that a very close approximation to the atomic weight of strontium, for example, could be obtained, by interpolation, from those of magnesium, calcium and barium.

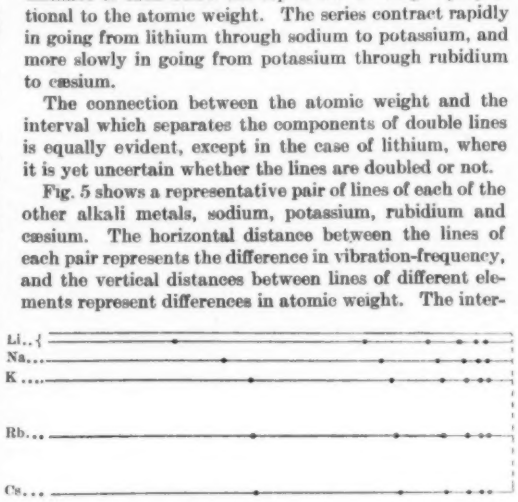


Fig. 4.—Spectra of Alkali Metals, Spaced According to Atomic Weight.

The correct theory of the vibratory system which emits the variously colored rays of a spectrum is unknown. The displacement of spectral lines in the magnetic field suggests the presence of electrons, oscillating about positions of equilibrium conditioned by the nature of the atom or molecule. The theories already advanced have led to very valuable results, and the rates of vibration of the lines that form a series in the spectrum of an element can be computed from each other very accurately by empirical formulæ. The most interesting characteristic of these formulæ is the presence in all of them, of a common constant, representing a rate of vibration which is independent of all the chemical elements. In the correct theory, doubtless, this rate of vibration will play a fundamental rôle as the embodiment of a law applicable to all ponderable matter. The present state of spectroscopy may be likened to the state of astronomy in the period between Kepler's discovery of the laws of motion and Newton's discovery of the law of universal gravitation.

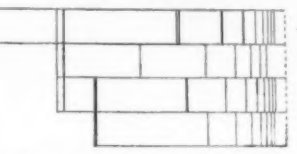


Fig. 3.—Spectrum of Cæsium.

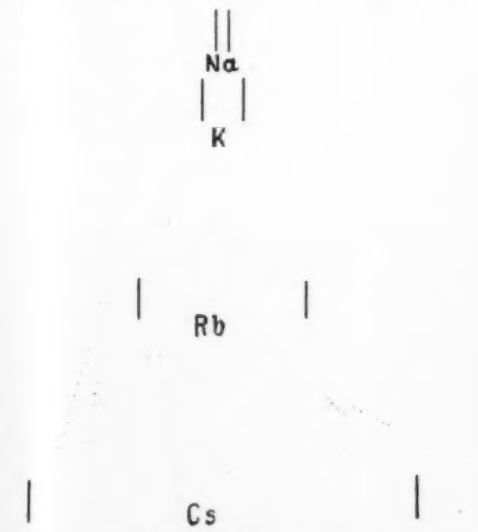


Fig. 5.—Intervals Between Parts of Lines of Sodium, Potassium, Rubidium, and Cæsium.

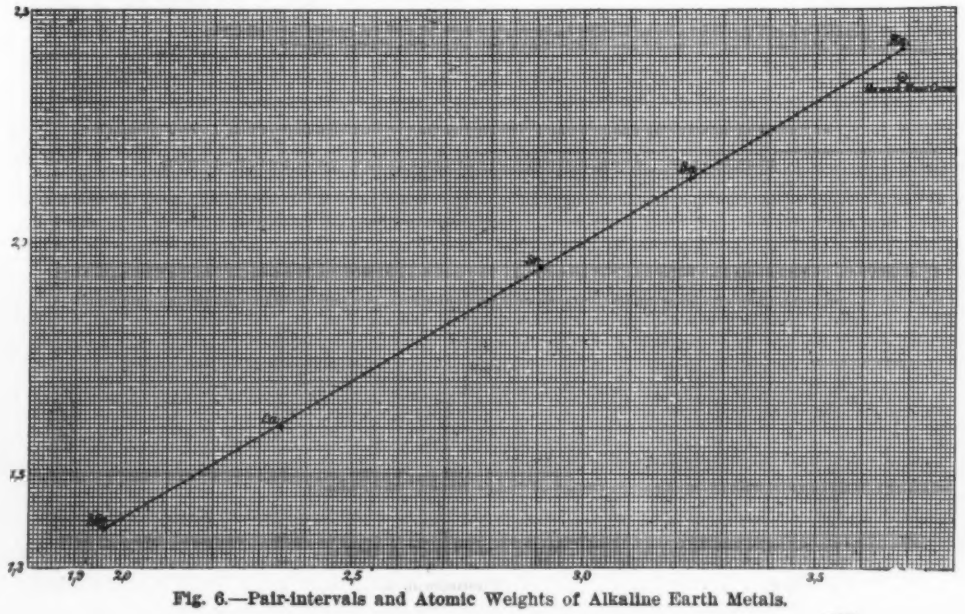


Fig. 6.—Pair-intervals and Atomic Weights of Alkaline Earth Metals.

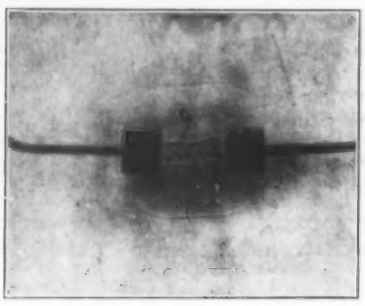
The Micro Indicator

With increasing speed it became necessary to restrict the movements of the pencil lever and the paper drum of the indicator so as to make smaller diagrams. Some makers of indicators furnish small drums for high-speed work. This means of avoiding distortion due to inertia has been carried to a limit in the micro indicator invented by a German by the name of O. Mader. This instrument traces on smoked glass, a minute diagram which is magnified 40 diameters by means of a microscope for measurement and analysis, or may be reproduced upon an enlarged scale photographically, or by means of a special reflecting and magnifying device. It is said that the instrument may be used upon internal combustion engines running at a speed as high as 3,000 revolutions per minute.—*Power.*

Legibility of Colored Advertisements

The French publication *Le Courrier du Livre* reports on some interesting experiments which have been made regarding the most favorable color combinations for reading at a distance. It was found that the most legible print was black upon yellow background. The order of merit obtained for different combinations is somewhat surprising, and is as follows: (1) Black on yellow; (2) green on white; (3) red on white; (4) blue on white; (5) white on blue; (6) black on white; (7) yellow on black; (8) white on red; (9) white on green; (10) white on black; (11) red on yellow; (12) green on red; (13) red on green.

It will be noticed, among other things, that the customary combination of black upon white comes sixth in the list, about half way down.—*Cosmos.*

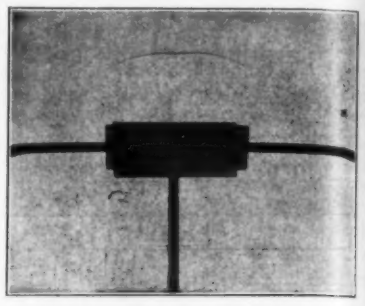


Photograph 1.

Photographing Sound*

A Fine Demonstration of Wave Motion

By Prof. Arthur L. Foley and Wilmer H. Souder



Photograph 2.

At the Chicago meeting of the American Physical Society in 1905, the senior author of this paper exhibited photographs of interference and diffraction fringes about electric discharges and fluid streams, taken by what might be called the point source shadow method.[1] The light from a point source is allowed to fall directly upon a photographic dry plate several meters distant from the source. About half way between the source and the plate is placed the fluid stream or whatever is to produce a shadow on the plate. Say the object is a stream of warm air issuing from a glass tube. The air stream maintains for a time a more or less definite lateral surface and produces diffraction fringes on the plate. The light is refracted on passing through the stream of air of density differing from the air about it, and so the stream casts a sort of shadow on the plate. The method is so sensitive that it gives a shadow of a stream of water in water. Inasmuch as a sound wave in air consists of a compression and rarefaction, the method should enable one to photograph the shadow of a wave, provided a sufficiently strong instantaneous point source of light is obtainable. Mr. Wilmer H. Souder, while teaching fellow at Indiana University, undertook the problem and succeeded in obtaining sound wave photographs, but discontinued the work to accept a position elsewhere. The writer continued and extended the work, and succeeded in obtaining a light source many times as intense as the source previously used—so intense that, in photographing sound waves, no further increase is desirable.

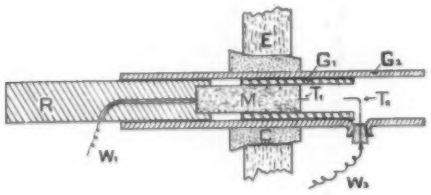


Fig. 2.

The general arrangement of the apparatus in this experiment is shown in Fig. 2.

The sound wave is produced by an electric spark at the spark gap S, which will be called the sound gap. The light is produced by a second spark at the illuminator gap I, which will be called the light gap. If the sparks at I and S are simultaneous the light from I passes S before the sound wave emerges from behind the spark terminals. If the time interval between the sparks is any considerable fraction of a second the sound wave at S passes out of the field before the light from I reaches S. But when the interval between the two sparks is properly timed the sound wave at S casts its shadow on the photographic dry plate P.

The spark gaps S and I are connected in series to the spark knobs K, K_0 which receive sparks from T, T_0, the terminals of a large electric induction machine having four rotating mica plates 30 inches in diameter, driven by a variable speed electric motor. The length of the spark gaps T–K and T_0–K_0 is adjusted by sliding T and T_0 horizontally, or by moving K and K_0 vertically. Glass plates G and G_0 about 20 centimeters square are fastened to a wooden bar or rod R, arranged so that it can be rotated on a horizontal axis. In the position shown in the figure the plates are directly between the spark knobs T and K, and T_0 and K_0, thus preventing a spark. A quarter turn of the handle of the rod R removes the plates and allows the spark to pass. In practice, however, it was found best to make the spark gaps T–K and T_0–K_0 just long enough to prevent sparking when the glass plates are out of the field. Rotating the rod then causes a spark just as the edges of the plates pass through the gaps.

To get a strong sound wave at S and an intense light at I, the sparks to the knobs K, K_0 should be heavy, consequently from one to three Leyden jars L, L_0 are put in multiple with each of the jars on the machine itself. Most of the work was done with one additional jar connected to each of the machine jars.

The knobs K, K_0 are connected to the gaps S and I through a large commutator C. Thus the direction of the spark at the gaps is readily changed. It was found that the apparatus worked about equally well with the spark in either direction. The chief effect of reversing the spark direction appeared to be a slight change in the time intervals of the sound and light sparks.

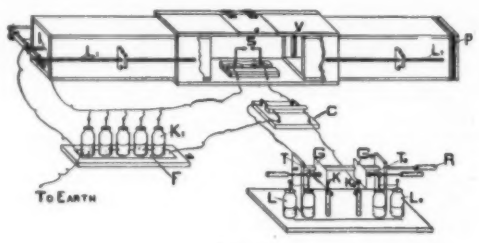


Fig. 1.

The sound gap S is in series with the light gap I, nevertheless the spark at S occurs before the one at I, because of the capacity K_1 which is in multiple with the gap I, as shown in the figure. The capacity K_1 consists of from two to eight Leyden jars of the usual type, standing on a sheet of tinfoil F, with one coat connected to earth. The time interval between the sound and light sparks depends on the capacity K_1, the greater the capacity the greater the interval. However, it is not at all necessary to have here a variable condenser or one made up of small units. One can vary the capacity K_1 between rather large limits and still keep the proper time interval by varying the circuit in other ways. The time interval is increased by decreasing the capacity L, L_0, by decreasing the length of the spark gaps T–K and T_0–K_0, by decreasing the length of the sound gap S, and by increasing the length of the light gap I, the last having the greatest effect. One can vary the capacity K_1 by 100 per cent and readily maintain an approximately constant time interval between the sound and light sparks by merely changing the length of the light gap. The length of this gap is adjusted by means of the lever arrangement L_1, L_1, as will be understood by reference to both Figs. 1 and 2.

Fig. 1 is a cross section of the light gap, the spark taking place between the terminals T_1 and T_2. T_1 is a short piece of No. 24 magnesium wire in the end of a metal cylinder M which is fastened in the end of a hard rubber rod R about 1.4 centimeters in diameter and 10 centimeters long. A wire W passing through a hole drilled in the rubber rod R connects the metal cylinder M, and therefore T_1, with one terminal of the electric machine. G_1 is a glass tube 0.7 centimeters in diameter and 5 centimeters long, fitting tight in a glass tube G_2, which is 1.4 centimeters in diameter and 18 centimeters long. G_2 passes through a cork C in the end E of a wooden box made of inch lumber. The rubber rod R slides back and forth (like a piston) in the tube G_2, and thus moves M back and forth in the tube G_1, and so changes the length of the spark gap T_1, T_2. Fig. 2 shows how R is connected to the lever arrangement L_1, L_1, which passes to the other end of the box and enables the observer there to change the light gap at will while the sparks are passing, and thus regulate the time interval, and consequently the size (diameter) of the sound wave.

T_2 is a piece of No. 24 magnesium wire passing through a cork to the wire W_2 connecting with the terminal of the sound gap. The other end of T_2 is bent at right angles as shown in the figure and adjusted so that the spark takes place along the axis of the tube G_1. The wire T_2 is so small that its shadow is practically negligible. The source is thus an end on spark—itself practically a point source. Considerable light must be reflected from the end of the cylinder M and the walls of the glass tube G_1, the tube acting as a sort of gun to direct the light toward the photographic plate. But inasmuch as the tube is only seven millimeters in diameter and the plate is several meters distant, the entire source is relatively a point source.

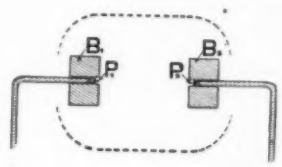


Fig. 3.

The light gap is at one end, the photographic plate at the other end, and the sound gap near the center, of a long light-tight wooden box or tube consisting of three sections, the two end sections telescoping into the central section, all painted black inside. This combination permits of a quick and independent variation of the distance between the light and sound gaps, and between the sound gap and the dry plate.

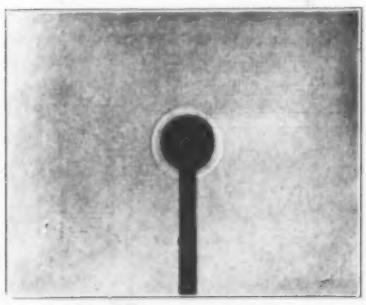
The central section of the tube is 4 feet long and 14 inches square inside. The end sections 3 feet long and 12 inches square inside, all made from planks 1 inch thick. Two additional sections, not shown in the figure, were sometimes used to get still greater distances between the gaps. Most of the pictures shown in this paper were obtained with the sound gap about 130 centimeters from the light gap, and about 1 meter from the dry plate.

The front side of the central section of the box is cut away in Fig. 2, to show the general arrangement of the sound gap.

Fig. 3 shows the details of the gap itself. P_1 and P_2 are the platinum terminals between which the sound

* Reproduced from the *Physical Review*.

[1] "Diffraction Fringes from Electric Discharges and from Fluid Streams," A. L. Foley and J. H. Haseman, *Physical Review*, Vol. 20, 1905, page 399.



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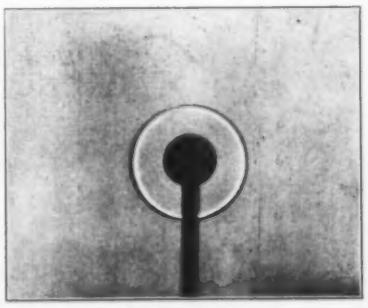

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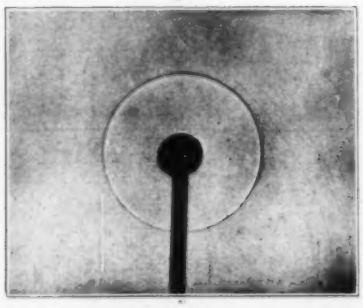

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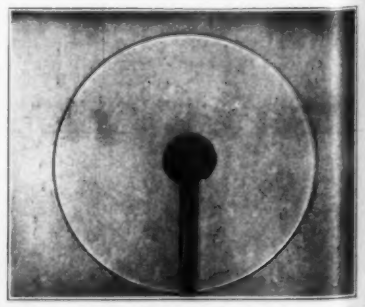

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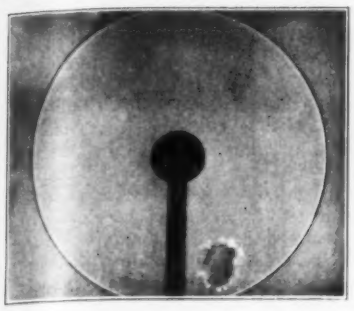

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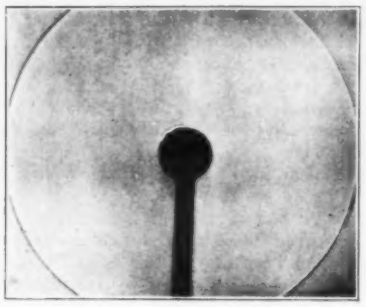

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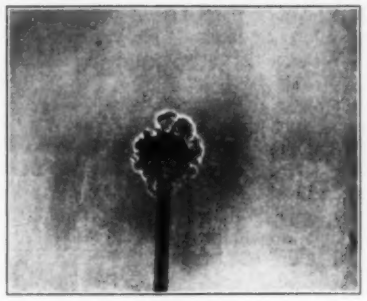

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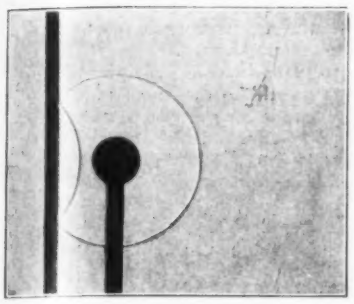
Photograph 10.



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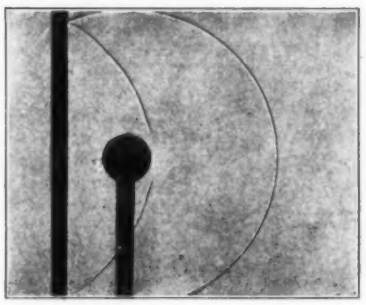

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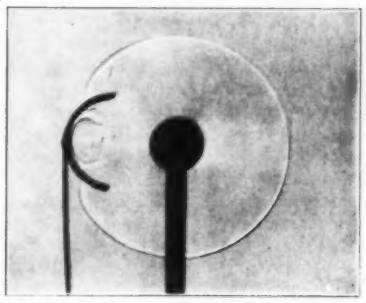

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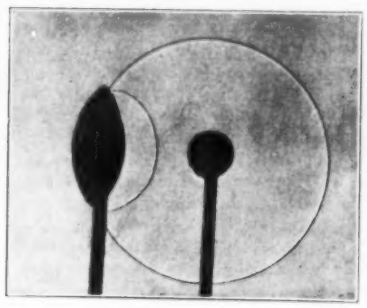

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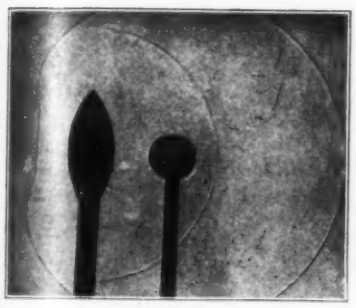

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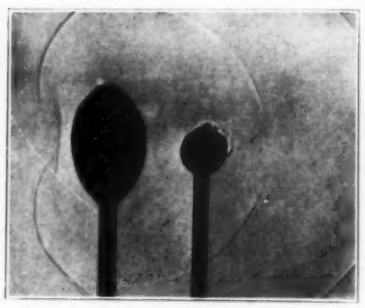
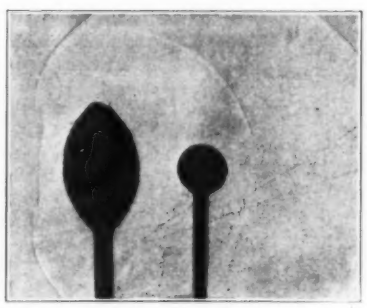


Photograph 16.



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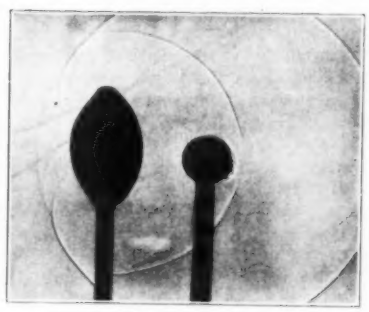

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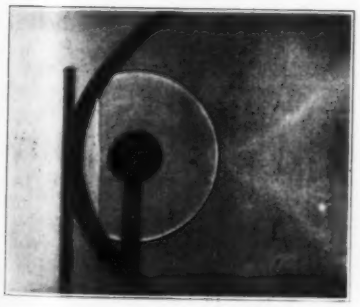

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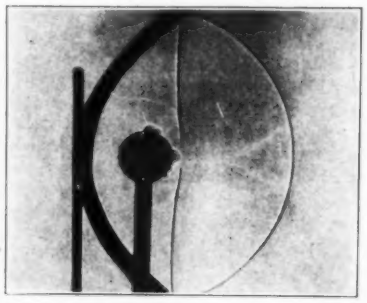

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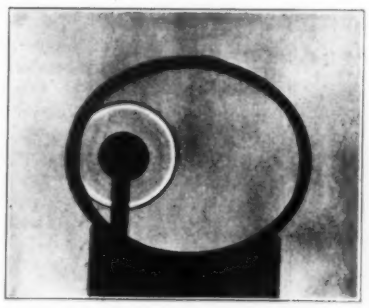

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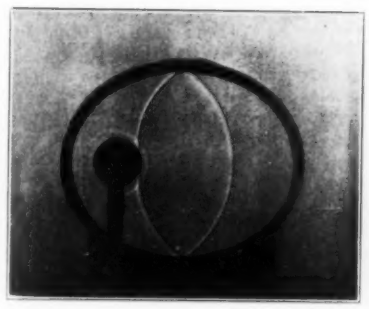

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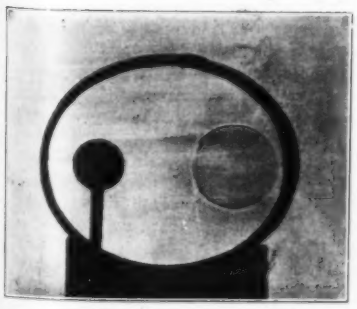

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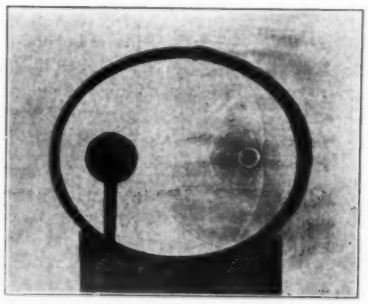

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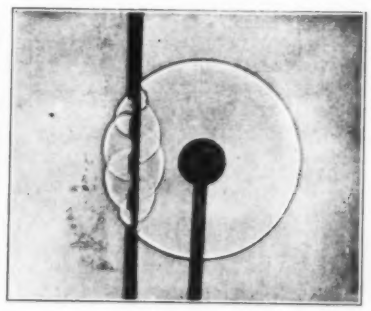

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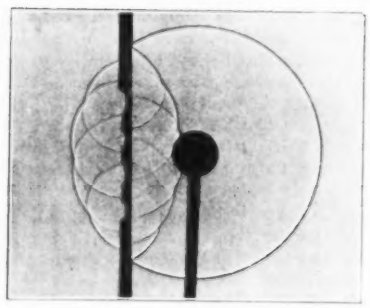

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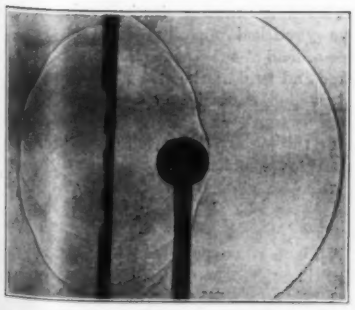

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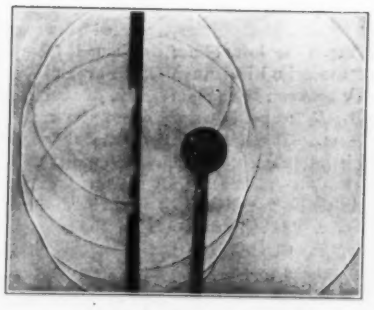

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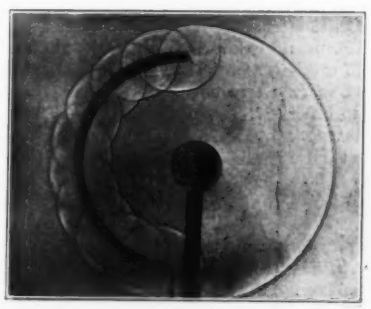

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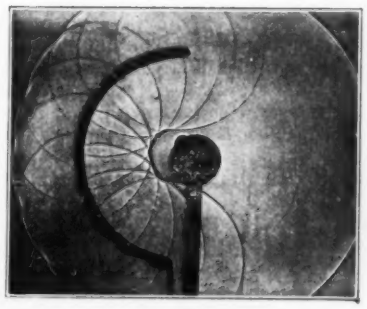


Photograph 30.

spark occurs. These consist of short pieces (0.5 centimeters long) of No. 20 platinum wire soldered in the ends of brass rods bent as shown. The brass rods are held by wooden blocks arranged to slide snugly between two cleats or guides fastened on a wooden base, permitting an easy adjustment of the length of the sound gap. The two halves of the sound gap are adjusted so as to be in the same plane with the light gap so as to give but one shadow of the terminals on the photographic plate, and also, as will be explained later, to give the best shadow of the sound wave.

The sound gap must be made long enough and the intensity of the spark great enough to produce a strong sound wave, if a distinct wave shadow is to be obtained. Consequently more or less light is produced at the sound gap, where it is not wanted. Moreover, the sound gap is much nearer the dry plate than is the light gap.

The photographic plate P is carried in an ordinary 8 by 10-inch plate holder placed in the reversible back taken from an 8×10 camera. The end of the box was arranged to fit the camera back, light tight, in either position, of the plate. When the plate holder is removed the sound wave shadow falls directly on the ground glass of the camera back, and is distinctly seen by an observer looking through the glass along the axis of the tube; that is, with his eyes in line with the light and sound gaps and the center of the ground glass. If the experiment is carried on in a darkened room the wave shadow on the ground glass can be seen at a distance of several meters even when the glass is viewed obliquely, therefore, the waves can be seen by several observers at the same time. Indeed the camera end of the box may be removed entirely and the shadow be allowed to fall on a white screen, or better, on a large sheet of white paper, and the waves be seen by reflection. The author has used this method in exhibiting the waves simultaneously to a number of observers. The screen is placed so that the light strikes it obliquely. This gives a distorted image of the waves, but it enables one to seat all the observers in a single group in front of the apparatus.

In Fig. 2 the connecting wires are shown looped in the conventional way in order that the connections may be easily traced. In the experiment the wires were run through glass insulating tubes and as nearly straight as possible. Most of the connections were soldered. In fact many precautions must be taken if one is to obtain even an approach to regularity in the time interval between the sound and light sparks. One must be able to regulate the time interval and maintain it approximately constant, or he may expose photographic plates by the dozen and not once catch the sound wave in the position desired. By experience the writer finds that the following conditions give the best results:

The connecting wires should be of ample size. Small wires (No. 30) appear to slow down the spark and so decrease the intensity of the sound wave and the brightness of the light spark. And the tendency of the discharge to jump from the wires is much greater than when larger (No. 14) wires are used.

The Leyden jars, particularly those on the electric machine and in multiple with it, should not have the usual dangling chain for connection with the inner surface. The connection between the links of the chain and between the chain and the metal lining of the jar is entirely too haphazard to produce the regularity of charge and discharge required in this experiment. The dangling chain is a makeshift in any case.

In this experiment the jars were of the type frequently furnished with large oscillator sets. The short metal rod and dangling chain were replaced by a long rod—reaching almost to the bottom of the jar. On the end of the rod there was soldered a star-shaped disk of thin spring copper with the several radial arms bent so as to make spring contact with the inner tin foil coat of the jar. The results obtained with such jars are far more regular than those which are obtained when using chain connection jars.

Let us suppose the capacities L, L_6, of Fig. 2 consist, respectively, of three Leyden jars, including the one on either terminal of the machine. Besides the Leyden jar capacity there is the added capacity of the machine itself, which is considerable in the case of a machine of the size and construction used in this experiment. Suppose further that six Leyden jars are used as the capacity K_1 and that the sound gap S is made about 3.5 centimeters long. The speed of the electric machine is then adjusted so that sparks will almost, but not quite, pass when the gaps TK and T_6K_6 are made, say, 6 and 7 centimeters long respectively. As explained elsewhere a spark will then occur when the rod R is rotated so as to bring the edge of the glass plates, G, G_6, between the spark knobs. Sparks continue to pass if the glass plates are not immediately rotated out of the field. By a rapid to and fro rotation of the plates single sparks can be produced at will. This may be done by the observer himself, but preferably by an assistant. The observer stations himself so as to view the ground glass normally and by pulling the lever L_1 makes the light gap very short, say 1 centimeter long. The assistant then produces sparks at regular intervals, say 1.5 seconds. If these intervals are not approximately constant the time intervals between the sound and light sparks will vary greatly due to variation in the ionization of the air about the spark gaps, the potential of the Leyden jars, etc. At every spark the observer sees the shadow of the sound gap terminals and, if the interval between the sound and light sparks is within the proper limits, he sees also the shadow of the sound wave produced at the sound gap. If he sees no sound wave at all, but sees about the shadow of the terminals a cloud resembling a puff of smoke, it indicates that the time interval between the sound and light gaps is too long, that the sound wave has passed

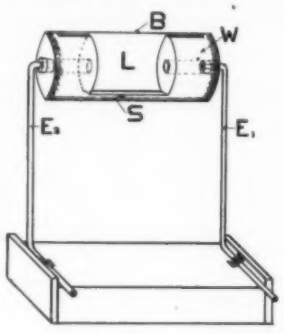


Fig. 4.

beyond the limits of the field and that the hot air from the spark has had time to pass out from behind the sound gap terminals, as shown in photographs 9 and 10. The time interval must be made less. Since the length of the light gap is already a minimum the interval should be decreased by decreasing the capacity K_1 by removing one or more jars.

If the observer sees neither sound wave nor cloud about the sound gap terminals it indicates that the interval between the sound and light sparks is so short that the sound wave has not had time to emerge from behind the terminals—rather from behind the cylindrical buttons shown in Fig. 3. The observer readily increases the interval by pushing the lever L_1 and thus lengthening the light gap. If the latter is made much longer than the sound gap, sparks will not pass at the light gap. The best illumination is obtained when the light gap is about two thirds as long as the sound gap, say about 2.5 centimeters long. If at this length the interval between the two sparks is still too short to show the sound wave, the interval is increased by increasing the capacity K_1. To get the best results it may be necessary to vary the lengths of the machine spark gaps and possibly the length of the sound gap. The latter is reached through a door or lid in the central section of the box. Several adjustments and trials may be necessary before the sound wave appears. When it does appear it repays all the time spent in trying to get it, for—if the conditions under which

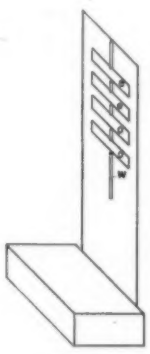


Fig. 5.

the wave is formed are at all favorable—the wave shadow will stand out with surprising definition and brilliancy whether reflected, refracted, or diffracted.

At first thought it might appear that the sound waves are spherical and that their shadows should be disks, not circles, as shown in the accompanying photographs. In the case of a linear spark the waves are not spherical, but cylindrical—with curved ends. In Fig. 3 the dotted lines represent a longitudinal section of the cylindrical wave that one would expect from a spark between the points P_1, P_2. The cylindrical buttons B_1, B_2 keep the wave cylindrical until it passes beyond them. The wave then takes on curved ends due to diffraction, but the intensity of the wave at the ends is far less than on the sides. In Fig. 3 the intensity of different parts of the wave is indicated by the breadth of the dotted lines. That this representation is valid is shown by photographs 1 and 2. To obtain these pictures the sound gap was turned at right angles to the position shown in Fig. 2, that is, the sound spark was at right angles to the axis of the tube and therefore perpendicular to the path of the light from the light gap.

A moment's consideration will show why the wave shadows are always cross sections of the wave—why, in all the pictures except the first two, we do not see any shadow of the ends of the cylindrical wave. In the first place, the energy of the wave is relatively much smaller at the ends than at the sides. This means that the change in the density of the air is less at the ends than at the sides, and that light waves in passing through the ends of the sound wave suffer less change in their velocity than when passing through the sides of the wave.

In the second place, whatever deviation is produced in the light ray in passing through one end of the cylinder is largely counter-acted by the opposite deviation produced in passing through the other end.

The only rays of light that undergo uncompensated prismatic deviation are those that lie just inside the surface produced by drawing a system of tangents from the point light source to the sound wave. These light rays enter the sound wave with a large incident angle, pass along approximately parallel to the sound wave front without passing through the inner surface of the wave at all, and pass out near the other end of the lateral surface at a large angle of emergence. Such rays are deviated more or less and so change the otherwise uniform distribution of light on the plate, giving a shadow of that portion of the sound wave. In any case the only parts of a sound wave that give strong shadows are those to which tangents can be drawn that are parallel (approximately) to the light rays from the light gap. Thus the shadow closely represents a meridian section of the sound wave at right angles to the path of the light from the light gap.

Most of the work of these experiments was done with Cramer's Crown plates and a strong hydrochinon (contrast) developer. To save time the plates were developed and fixed in an Eastman tank, a dozen plates at a time. The time of development varied from 10 to 20 minutes.

DETAILS OF SOUND WAVE PHOTOGRAPHS.

Photograph 1. A longitudinal section of a sound wave from a linear spark at right angles to the axis of the tube, showing that the wave is cylindrical with approximately hemispherical ends. (Compare with Fig. 3.) In this position the light from the sound spark falls directly on the photographic plate and fogs it, and on this plate the light from the light gap superposes the shadow of the sound gap and the sound wave. Distinct sound wave shadows cannot be expected under such conditions. However the photograph shows that the wave form corresponds with the theoretical form shown in Fig. 3.

Photograph 1 shows also that *the luminous discharge in air at normal pressure is striated.* On the original negative the striations are quite distinct. Moreover, besides the principal sound wave the negative shows other systems of sound waves. This method of study promises to enlarge our knowledge of the conditions attendant upon the spark discharge in air.

Photograph 2. This photograph is the same as photograph 1, except that the direct light from the sound spark gap is prevented from falling on the photographic plate by placing between the gap and plate a small rectangular block of wood supported on a metal rod.

Photograph 3. A sound wave just emerging from behind the spark terminal. For this photograph and all the others except Nos. 1 and 2, the spark was axial with the tube, in the position shown in Fig. 2.

Photographs 4, 5, 6, 7, and 8 show the wave as it gradually travels outward from the source until it finally passes beyond the limits of the plate.

Photograph 9. Here the sound wave has passed beyond the limits of the plate and the hot air produced by the sound gap has had time to puff outward from behind the spark buttons. It will be noticed that in photograph 8 the puff has begun to emerge from behind the buttons.

Photograph 10. The puff at a still later time than shown in Photograph No. 9. The photograph shows how clearly changes of temperature and pressure are recorded by this method.

Photographs 11 and 12 show a wave reflected at the plane surface of a piece of glass plate about 10 centimeters wide and 20 centimeters long, held vertically a short distance from the spark gap, with the surface of the plate parallel with the gap.

Photograph 13. This shows a wave (cylindrical) reflected from a concave cylindrical reflector. The reflector was made from a piece of lead about 6 centimeters square bent around a gas pipe and held at the end of a vertical strip of sheet brass to which the reflector was soldered. Note the reflected wave front, and the reflected and diffracted waves about the edges of the reflector which are parallel to the spark gap.

Photograph 14. Wave reflected from a concave surface, here the surface of a cylindrical convex lens as described in the next paragraph.

Photograph 15. A plane wave produced by placing the spark gap at the principal focus of a convex lens of sulphur dioxide gas. The lens was constructed as follows:

A block of wood, *W*, Fig. 4, was shaped like a cylindrical lens about 10 centimeters long, 4 centimeters wide, and of the thickness desired,—almost 2 centimeters in the case of the lens used in photograph 15, more than 3 centimeters in photographs 16, 17 and 18. To form the lens space *L* a section 5 centimeters long was cut from the center of the block, except for a narrow strip *S* at the bottom, to hold the end sections in place. A rubber band *B* was stretched between the two extreme ends at the upper edge of the block and a portion of the thin edge of the block cut away just under the band so the band might be as free to move as possible. The sides of the block near the ends and the lower cross strip (the surface shaded in the figure) were coated with a light coat of thin shellac varnish. Before the shellac had time to dry the block was covered with a single collodion film with the lap on the wood strip *S*, and everywhere made gas tight by the shellac; thus forming between the collodion surfaces a cylindrical gas lens, *L*. The rubber band *B* was to keep the surfaces in position and still permit of considerable distortion of the walls of the lens without tearing the film. This was not possible when the films were pasted on lens forms having both an upper and lower rigid strip (*S*) and when the films were pasted to the form up to or close to the lens space *L*. A very few sound sparks invariably sufficed to rupture the films on such lenses, the rupture always being on the side away from the sound spark. There was no rupture when using a lens of the construction shown in Fig. 4. The points of attachment of the edges of the film are so far apart that the film has considerable freedom of motion, and is therefore not so easily ruptured. Obviously the freedom of motion is still further increased by the use of the rubber band *B*

Collodion films are exceedingly strong considering their thickness, but they are rather stiff and they will not stretch without tearing. The writer found that a film made of so-called "liquid skin" is more flexible and extensible. The formula for the liquid skin is: 92 grammes collodion, 5 grammes Canada balsam, 3 grammes castor oil. When thoroughly mixed and free from air bubbles a small quantity of the fluid is mixed with three or four times its volume of ether. This is then poured into a glass dish with a flat bottom, or on a piece of glass plate, and the dish or plate drained at once by standing on edge. When the film is thoroughly dry it is floated off in the usual way—by allowing water to creep in between the film and the glass. The film should dry thoroughly before one should attempts to mount it.

The gas is introduced into the lens *L* through a small glass tube E_1 connected with the gas generator. The gas escapes from the lens by means of the glass tube E_2, to which a long rubber tube is attached so that the gas can be passed into a hood or out at a window. The tube E_2 is larger than E_1, so that there may be no danger of the gas pressure increasing in *L*, and rupturing the film. A continuous flow of gas through the lens was maintained whenever the lens was in use. The sulphur dioxide gas was generated by the action of hot concentrated sulphuric acid on copper and the flow of gas controlled by regulating the heat. The pressure of the gas in the generator was maintained at about 5 centimeters of water, as indicated by a manometer attached to the generator.

All of the lens photographs show the original wave, the wave reflected from the convex surface of the lens, the refracted wave, and the wave diffracted about the upper and lower edges of the lens. The film of the lens in photograph 15 has a minute perforation in it through which the SO_2 gas escapes. The path of the escaping gas is clearly indicated.

Photograph 16. A sulphur dioxide lens—thicker than the lens of photograph 15. Here the divergent sound wave has been rendered convergent.

Photograph 17. A carbon dioxide lens. Here the refracted wave is still divergent; that is, the spark gap is nearer the lens than the principal focus.

Photograph 18. A hydrogen lens. Here, contrary to what one should expect from the velocity equation, the refracted wave has suffered practically no change in curvature. In fact the several pictures appear to indicate that the velocity of the sound wave of an explosive character is not given by the Newton equation. This fact has been observed by others.[2]

Photographs 19 and 20. Sound waves reflected from a parabolic reflector made from a sheet of lead 6 centimeters wide and 20 centimeters long and supported by an upright strip of brass as shown in the photographs. The spark gap was placed at the focus of the parabola. The reflected wave is plane except (photograph 20) for the disturbance produced by the hot air through which the central part of the wave must pass.

Photographs 21, 22, 23 and 24 show four different positions of the sound wave reflected by an elliptical reflector. The reflector was made from a strip of sheet lead about 5 centimeters wide and 25 centimeters long bent into the form of an ellipse and the two ends of the lead sheet soldered together. It was supported on a block of wood cupped to fit it. The brass rods that support the spark terminals are so far apart (see Fig. 3) that the lead reflector is readily placed in position between them. The sound wave is produced at one focus and in photograph 24 it has almost reached the other focus. The expected symmetry of the direct and reflected waves at the center of the ellipse is shown nicely in photograph 22.

Photographs 25, 26, 27 and 28 show four positions of a sound wave reflected from and transmitted by a diffraction grating. The grating was made by cutting four equal and equally spaced rectangular slits (*O*, Fig. 5) in a strip of sheet tin 6 centimeters wide and 18 centimeters long. The slits were 7 millimeters wide and 3.5 centimeters long, with a strip of tin 7 millimeters wide between the openings. The tin was tacked to a wooden block which served as a supporting base. The grating is placed with its apertures parallel with the spark gap. In this position the shadow on the photographic plate is edge on and the location of the apertures is not shown on the plate. To correct this fault pieces of heavy wire (*W*, Fig. 5) were soldered to the upper, lower and intermediate strips of tin, so that an edge on shadow of an aperture is narrow, of a reflecting surface it is broad.

Both the reflected and transmitted system of waves are in complete accord with Huygens's principle. It seems to the writer that such photographs as these, or better, a chance to see the waves themselves, might be used by a teacher to give a concrete and definite idea of Huygens's principle and deductions from it, to students who have difficulty in forming mental images. Reality would be given to such terms as secondary waves, center of disturbance, pole of wave, wave front, common tangent, diffraction, etc.

Photographs 29 and 30. These pictures were made by substituting a curved grating for the plane grating of the last four photographs. The grating is similar to the plane grating already described except that it has eight slits instead of four, and is cylindrical—having been curved over a piece of gas pipe. It was intended that the spark gap should be on the axis of the cylinder but it was accidentally displaced slightly before the photographs were taken. This explains why the transmitted and reflected wave systems are not symmetrical with respect to the grating and the spark gap.

[2] P. Vielle, *Comptes Rendus*, 127, p. 41–43, 1898.

Lugs, Facings and Bosses*

By Francis W. Shaw

Lugs, facings and bosses are but details, yet lax consideration of their form or position may result in enhancement of cost and weaknesses in construction.

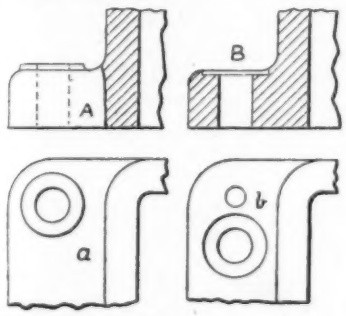


Fig. 1.

For instance, a projecting boss, as shown at *A*, Fig. 1 has several disadvantages. It is necessary that the would-be designer know these disadvantages. First, in many

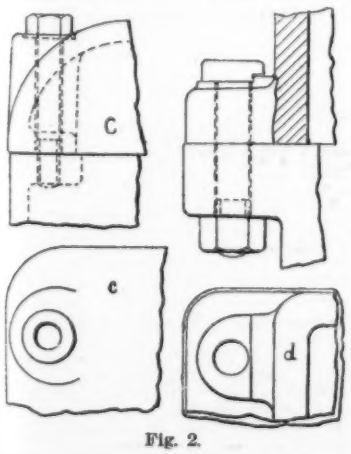


Fig. 2.

* Reproduced from the *English Mechanic and World of Science.*

cases the boss, or facing, would entail a loose piece in the pattern, apt to get out of place in the mold during ramming, and, when removed, apt to get lost in the sand. It not only entails extra work for the molder, but also extra work to the fitter in trimming it up. It hinders the painter, and particularly so if the modern style of finish by filling and rubbing down is adopted. If out of position, it has a very ugly appearance.

In modern design all such excrescences are gradually disappearing, the method adopted being that shown at *B*—a simple counterbore in a bossless flange, to give a level seating for the nut or bolt-head.

If, however, the parts to be bolted together are as shown in Fig. 2, at *C*—made so in order to correspond in outline with other parts, or for the sake of homogeneity in appearance—a lug is better than a boss, being less conspicuous, and needing no trimming. Such a lug should never be concentric with the hole. If made as

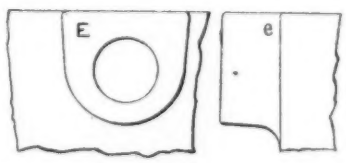


Fig. 3.

shown in plan *C*, errors in positioning the hole will be less apparent.

In that rare case where a facing is necessary (such a case is shown at *d*), it should be carried back to the main part of the casting, as shown. This particular form of facing serves as a key to prevent the bolt turning while tightening the nut.

Fig. 4 shows a case where the bracket to be attached is made to correspond in outline with the facing. Many designers would have made both the bracket and the facing with four uniformly-rounded corners, as a consequence of which it would be necessary for the molder to joint down in the mold to allow the pattern to be withdrawn. With the form shown, the joint in the mold would be flat. Fig. 3 is a similar case, serving the same end.

It might be argued that appearances are somewhat spoilt by these changes in shape. But what is it that rules or determines fitness in this respect? Is it not merely custom—ocular training? In the old days, when the Corinthian column, the flute, the bead, the ogee, had their vogue in machine construction, these were regarded as things of beauty. To-day, who would wish to go back to these types? In the eye of the present beholder, the new forms—simple in outline and unornamented—are vastly superior. He sees in them not only harmoniousness of form, but an incorporate fitness to

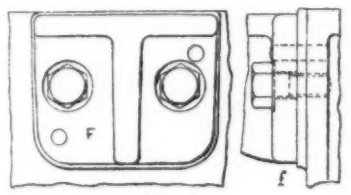


Fig. 4.

their end. He sees how this piece in form is governed by the exigencies of machining, the other by some attempt to rationalize the theoretical for some manufacturing reason. He sees not only the outward and visible forms, but the inward and invisible—the forethought of the designer expended not only to make each member a fitting part to a completed whole, but also to make it capable of filling every requirement of the pattern-maker, the

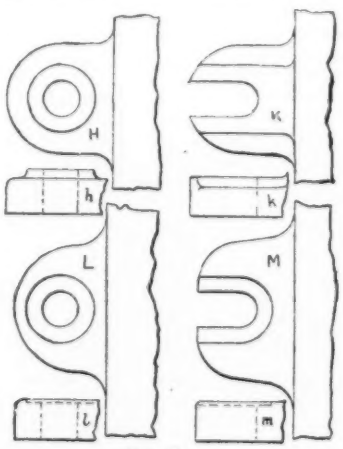


Fig. 5.

molder, the machinist, the erector, in its journey toward completion. A feature, no matter how symmetrical, that shows in its form neglect of some item that goes to make up a whole consistent from every point of view, to him is but an expression of uglincss. A little excrescence here or there, if it has served a useful purpose, is to him not an eyesore which ought to be removed by the expenditure of labor, but an actual beauty, in that its very presence there denotes a necessity for existence.

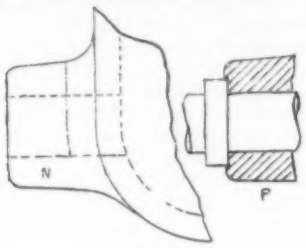


Fig. 6.

As a matter of fact, if evidence existed that such an excrescence had been removed, and labor wasted in its removal, in all probability the excrescence would be ugly in its absence!

Lugs should never be made as shown at *H* or *K*, Fig. 5. They are much stiffer if made as at *L* and *M*, simply counter-bored as at *l*, or recessed with an end-mill as at *m*. Or, if processes demanded, the lug might be machined right across, and the sharp corners trimmed off.

Bosses should always be well tapered outward, not merely for the molder's convenience, but for appear-

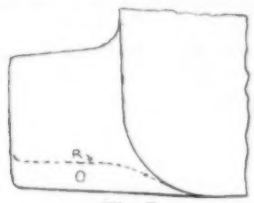


Fig. 7.

ance' sake. Made parallel, they have an "undercut" appearance, that is, taper the wrong way. The radius at the "merging"-point should be proportionate to the size of the boss. Unless a boss is to be faced for a collar to bear against, it is neater and cheaper to leave it black (unfaced), the outer corner being neatly rounded in the pattern. In certain cases a boss may be counterbored as shown in Fig. 6 at *P*, saving the trimming that would be necessary were the boss faced right across.

When a boss extends up to a rounded corner, as shown in Fig. 7, it should be gradually merged into the body with a reverse curve, as shown; but if some distance from the corner, the internal radius would be used as at *R*.

"Plumboxan"

At the meeting of Section 8 of the Convention "Deutscher Naturforscher und Aerzte in Münster i. W.," in September, 1912, G. Kassner presented a paper on "A New Method for the Production of Oxygen by Chemical Means."

Tessié du Montay showed that alkali manganates become soft on heating and that, on treating with steam, they decompose with the separation of alkali hydroxides. On mixing sodium manganate with sodium-*m*-plumbate in molecular proportions, Kassner obtained an emerald green compound, or solid solution, which he calls "plumboxan." When steam is allowed to act upon this compound at an elevated temperature, oxygen is given off; upon passing air over the de-oxygenated "plumboxan," oxygen is replaced in a very short time. Again, "plumboxan" can stand higher temperatures without becoming soft and losing its porosity than alkali manganates. It is a stable compound and forms a very good means for the production of oxygen. It is necessary that all traces of carbon dioxide, as well as dust, etc., be removed from the air before it is passed over the "plumboxan." The reaction occurs according to the following equations:

$$Na_2PbO_3.Na_2MnO_4 = Na_4PbO_4 + MnO_2 + O;$$
$$Na_4PbO_4 + MnO_2 + Air(O + 4N) = Na_2PbO_3.Na_2MnO_4 + 4N.$$

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

The "Double-field" Microscope

To the Editor of the Scientific American Supplement:

I have read with interest Dr. W. Thorner's article in your issue of November 2nd, 1912, entitled "A Double-field Microscope," in which the author states that "it is a somewhat singular fact, however, that no microscope had hitherto been made which would permit of the simultaneous observation of two preparations, or in other words, the direct comparison of two objects in the same field of view." This would indeed be a singular fact, were it true, which it is not. We invite your attention to the *Journal* of the Royal Microscopical Society for 1886, page 507, and to the *Journal* of the Royal Microscopical Society for 1910, page 14, from which you will see that the idea was worked out in 1886, improved in 1887 by Van Heurck, and again improved by the writer in 1910. Had Dr. Thorner been more careful in examining the literature on this subject, doubtless his claim would have been less positive and comprehensive. M. D. Ewell.

An Automatic Longitudinal Stabilizer for Aeroplanes

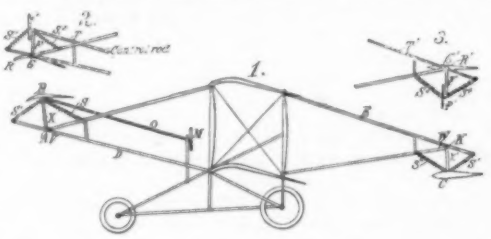
To the Editor of the Scientific American Supplement:

The following arrangement is based upon the same principles as the Doutre stabilizer, i. e., that with increase in speed there is an increase in the aerodynamic resistance, and *vice versa*, but is much simpler, doing away with the servo motor accelerator.

Referring to Fig. 1, *B* is the elevator rigidly attached to the arm *X* which swings on the point *A*. The elevator is controlled manually through the rod *O* and rocking post *M*. *S* is a spring connecting the upper end of rod *X* with the upper outrigger. *S'* is a similar spring connecting the same end of *X* with the lower outrigger which is extended past the junction *V* for this purpose.

The tail C, which is usually immovable, is suspended below the extremities of the rear outriggers by *X'* to which it is rigidly attached and capable of swinging around the pivot *K*. *S''* and *S* are suitable springs connected in a similar manner to those on the front elevator.

The operation of the above is as follows: The springs are so adjusted that when the relative velocity is just sufficient for sustension of the aeroplane, the elevator *B* and tail *C* are forced back against the resistance of the



springs *S'* and *S''* respectively, by the aerodynamic resistance that they encounter, just far enough for horizontal flight.

Assuming that the machine is in horizontal flight and some disturbance in the atmosphere causes the machine to point downward or plunge, as the machine points downward the speed will be increased, thereby increasing the aerodynamic resistance against the planes *B* and *C* and forces them back against the resistance of the springs *S'* and *S''* causing *B* to make a positive and *C* a negative angle with the line of flight, the air striking the under surface of *B* and upper surface of *C* produces a couple which causes the machine to rotate longitudinally around its center of gravity, and as the machine approaches a horizontal position the speed will again decrease as well as the resistance against *B* and *C* and the springs *S'* and *S''* will pull *B* and *C* into the normal positions, the springs *S* and *S* will damp out all tendencies for *B* and *C* to oscillate.

In case the motor fails, the speed of the machine will decrease, at the same time the wind resistance will decrease, and therefore *B* and *C* will move forward under the influence of the springs *S'* and *S''* causing them to assume angles opposite to that in the former case and, therefore, depressing the bow and causing the machine to assume a gliding angle. It is obvious that the aeroplane will tend to assume its minimum angle of descent, for then the relative speed will be just sufficient for sustension and the aerodynamic resistance against *B* and *C* will be the same as the resistance in horizontal flight.

As can be seen in Fig. 1, the operator can assume control of the machine at his will, the automatic action being not sufficient to prove inconvenient to him. The rear plane *C* is not controlled by him but is purely automatic in its action. Perhaps this method of maintaining the longitudinal stability would come under the class of inherent stabilizers instead of automatic, but it seems to occupy an intermediate position and therefore I adopted the latter for lack of certainty.

Of course the springs *S'* and *S''* would need to have a coefficient of resistance which increases more rapidly as the spring is extended than the resistances the planes *B* and *C* encounter as their angles increase; in other words as *B* is tipped back it will present more surface to the wind, thereby encountering more resistance the farther it was tipped back and if the resistance of the spring did not increase to a greater extent the plane *B* would be forced back till it was perpendicular to the line of flight.

Another method is shown in Figs. 2 and 3 which represent the front and rear controls, respectively. Instead of having the planes *R* and *R'* swinging through an arc of a circle as in Fig. 1, they are pivoted at *G* and *G'*; *P* and *P'* are plates with their planes normal to the line of flight; they are rigidly attached to posts *F* and *F'*, respectively, which are in turn rigidly fastened to the planes and, therefore, rotate about the pivot *G* and *G'* in conjunction with planes *R* and *R'*, respectively. Suitable springs are attached as shown in Figs. 2 and 3. They are attached in a similar manner to those in Fig. 2. The action is the same, there being this difference in the construction, that in the former case the wind pressure against the elevator and tail is utilized directly, whereas in the latter the resistance encountered by small planes placed normal to the line of flight and attached to the elevator and rudder is utilized.

I have used a sketch of a Curtiss biplane in describing the arrangement, but it is quite plain that it may be adopted with modifications by nearly any make of aeroplane. I hold no patent on the device and whoever is willing may utilize it. If it does not solve the problem of automatic longitudinal stability, it certainly will shed new light on that subject. William H. Dettman.

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